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Comparative Tracer Tests on Container and Window Glass Tanks

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Part I

• THE MOST DIFFICULT job of the actual operator of a glass tank is to separate the theorizing about the flow from the actually proved statements and make at least a fair estimate of the movement of the glass in a particular tank. A large number of authors have discussed this subject both theoretically and practically for many years.

Motion of the glass at any point in a tank is brought about by a combination of factors. The most important of these is the temperature difference. Molten glass always tends to flow in the direction of the lowest temperatures. In a majority of cases the motion due to a temperature difference is the most important and all of the other forces may be nearly disregarded. In the mind of the practical glass maker, motion due to the pull on the tank is the first thought. In most cases this pull is superimposed on the normal flow as an almost negligible effect. It must not be completely forgotten, however, as it may give just the push necessary to change the overall flow pattern. Another force normally disregarded because of dfficult calculation, but by no means negligible, is the friction between glass and tank blocks. Finally, there is the displacement force resulting from the introduction of batch and its subsequent swelling and contracting as it melts and changes to a glass. A discussion of the flow in any real tank must consider all the above forces. It must also consider the far more elusive differences between glasses. The steep temperature gradient in a furnace from top to bottom is dependent on the particular glass used. Although the gradient is not due only to heat absorption in the glass, some estimate of the gradient can be made by heat absorption measurements on the cold glass even at a single wavelength. Lacking actual depth temperature measurements, this is the best possible substitute. The temperature-viscosity curve of the glass should also be considered even though differences between glasses are normally not very great.

The movements in a generalized tank are fairly well known both from theory and experiment. The following might be considered to be a composite picture as presented by Flint and Lyle,[1] Preston,[2] Gehlhoff and Thomas[3] and others too numerous to mention.

In the section of the tank between the batch charging end and the hot spot, the movements are apt to be extremely confused due to the many forces. The batch rests on top of the already molten glass and, except in the case of the blanket type of feeding, does not cover the surface completely. The uncovered portions of the surface are strongly heated by the firing, while the glass underneath the batch is insulated and much colder. Freshly melted glass drops down beneath the batch piles aided by the convection currents which are always in the direction of the cold batch piles. This fresh glass flows downward and then goes in different directions. Some of it returns directly to the surface between the piles of batch. Some of it flows forward at some level between bottom and top and rises at or near the hot spot. This is probably the first glass to be drawn into the main glass flow toward the feeders or machines. At the same time two opposing forces are acting on the surface glass between the batch and the hot spot. Generally, the flow here is almost neutralized between the displacement push of the batch being fed into the tank and the opposed temperature difference tending to push surface glass back to the doghouse. Thus, a floating refractory body in this area is apt to travel erratically. If placed in the tank center laterally, it will usually travel slowly toward the hot spot but displaced to either side it may return and stick to a batch pile or to the cold wall of the tank. Constancy of charging is important since tracer experiments made on tanks charged with discrete piles of batch show varia-

tions in the tracer arrival in the finished glass, and if any variability in the batch, causes variations in the glass. The necessity for maintaining a temperature difference between the charging end and the hot spot in order to hold back the batch is too well known to comment on.

From the hot spot to the bridgewall or other end of the melting area the flow is much simpler but still fairly complex. It is simpler because in this section the effect of temperature difference almost completely determines the flow. There are two differences to consider. The difference in temperature between the hot spot and the end of the melter causes a relatively fast flow longitudinally down the tank. This flow is fastest on the surface and slower deeper in the tank. It generally is zero at a point about 0.4 of the total tank depth and below this neutral line the glass continually returns along the bottom toward the hot spot. Actually the extreme bottom glass moves very slowly, if at all, while the maximum of the return current is some distance off the bottom, usually at about 0.6 of the tank depth. The forward flow of the surface glass is usually quite fast in this portion of the tank and is sufficient to transport many times as much glass as is represented by the tank pull. In a long sheet glass tank the surface glass may move as fast as 100 feet/hour, transporting glass equal to 20 times the pull, while in a throat tank rates up to 30 feet/hour are recorded by Gehlhoff. This will transport glass equal to the tank capacity nearly three times in 24 hours, which is much greater than the highest pull rate.

Superimposed on this forward flow on the surface and back flow deeper in the tank is the effect of the cold side walls. These set up a temperature difference from center to side and cause lateral currents of glass. Thus the flow in this portion of the tank has been likened by Gehlhoff to two screws turning in opposite directions with both progressing toward the working end of the tank. How much this lateral convection is effective in mixing the glass is open to argument. In certain cases as seen later, it is most certainly negligible.

At the end of the melting section and beginnnig of the refining section there may be one of four designs. Some of the older sheet glass tanks were built with a narrow neck, with or without some raising of the bottom. This design is now obsolete. Its effect is discussed in the paper, "Effect of Changes in Tank Design on the Glass Flow." The more common design of sheet glass tanks now utilizes a shadow wall, generally adjustable in height above the glass, without obstruction to the mechanical flow of surface glass. The effect of this is a more or less abrupt change in the glass surface temperature. Any change in surface temperature upsets the glass flow by slowing down the surface glass. The excess flow from the melter has no place to go except to join the return current below the neutral line and return to the hot spot. This causes a plunging current slightly forward from the shadow wall. If the shadow wall is low enough, the glass coming back from the machine end of the tank finds a minor hot spot here and tends to rise to the surface. The effect of the mixing of the plunging hot glass and rising cold glass is a possible cause of blisters and seeds. Juan Erneto Peña a de Castro[5] has discussed this in a recent paper and found the blisters so caused principally contained oxygen.

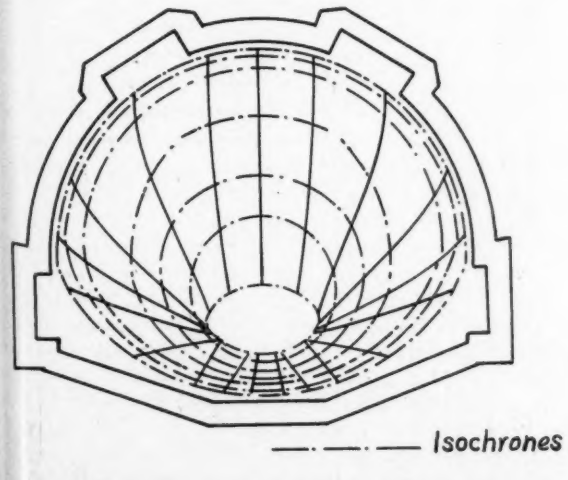
Generally, the shadow wall is high enough over the glass surface that it well serves its purpose of maintainin a lower temperature in the refiner without seriously uj setting the flow pattern. Next, the type of tank in which there is a surface obstruction across the full width of the tank with an opening under it to permit glass flow will be considered. The obstruction may be a submerged bridge wall or a *floater* on the glass surface which serves to lower the glass temperature rather abruptly in an amount depending on its depth in the glass. One can get a rough approximation of the temperature change caused by such a floater or bridge by multiplying the vertical temperature gradient at this point by the depth of the obstruction. The effect will, at all times, be somewhat less than this amount and depends somewhat on the velocity of the glass moving towards it. This floater was at one time called a skimmer, but it did a very imperfect job of skimming since, under the most common conditions, the surface glass simply ducked under the *skimmer* and reappeared as surface glass on the far side. Under other conditions surface glass was nearly stopped and deeper glass moved on. The condition under which surface glass is carried under a barrier has been termed *surface* flow, and the condition under which deeper glass passes under, *displacement* flow. These terms are relative since no distinct borderline exists. The two types may be shown by a transparent model of a tank using water or glycerine as "glass." Under *displacement* flow conditions (more commonly observed with water) a colored material such as fluorescein added to the liquid will flow down the surface to the barrier and then gradually fill the top layers of the liquid until the entire layer down to the bottom of the barrier is filled; after which it will escape into the *refining* end. When thermal currents are increased, however, *surface* flow takes over with the surface colored liquid ducking the barrier and coming up on the other side. In both cases some of the colored liquid returns lower in the tank to the hot spot. In either case in a glass tank the primary purpose has been fulfilled, since a lower temperature results. If the skimmer is further lowered into the glass so that it is in effect a throat as wide as the tank, we secure, theoretically at least, the benefit of a great reduction in glass temperature and the selection of a homogeneous layer of glass from the melter. Peyches mentions this and implies that it has been tried and works well but gives no details.

Finally, there is the throat which is used in the vast majority of glass tanks. The throat is the cheapest means of cooling the glass several hundred degrees. Since the presence of a central throat mixes the convection pattern in both the melter and refiner, it is impossible to get glass good enough for sheet glass from a throat type tank. The throat is a place of extremely high velocity glass flow. Peyches quotes measured velocities from 32 to 65 feet/hour. It must be much higher in some cases. This velocity depends on the height of the throat and the temperature differences across it. It also depends on the viscosity of the glass. This latter would appear to depend in turn on the distance of the throat below the glass level, since the lower one goes in the melter, the colder the glass (with the exception of a slight temperature inversion generally noted at about 0.6 of the depth). Experience seems to show, however, that surface glass plunges at the throat and forms a large part of the glass passing into the refiner. The *drop* throat which

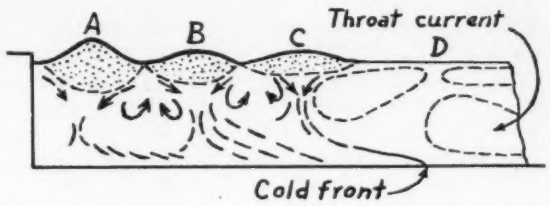
was quite popular some years ago, because of the increased life it gave the refractories, is no longer used by many large manufacturers despite resistance to wear without losing the benefit of its low position. The current in the throat is similar to that in the open tank which flows both forward and back toward the melter. The return flow through the throat was proved by Dr. J. C. Hostetter who inserted a thermocouple through the throat bottom and found a low temperature, characteristic of refiner glass, in the bottom portion and a high temperature, characteristic of melter glass, above it. The flow rate is, of course, low at top and bottom due to friction of refractory surfaces. Since measurements show that glass from the left side of the melter goes into the forehearths on the left side and likewise center glass to central forehearths and right side glass to right side forehearths, the throat must draw its quota of glass from the full width of the melter and give only slight mixing in passage.

Some recent model tank experiments reported by I. Sawai[6] show the possibility that with increased pull rates glass flow short circuits from doghouse to throat at a level about half the tank depth. This does not invalidate the results discussed here but shows that in a throat type tank it would probably be better to discuss *displacement* flow and *short circuit* flow instead of *displacement* flow and *surface* flow.

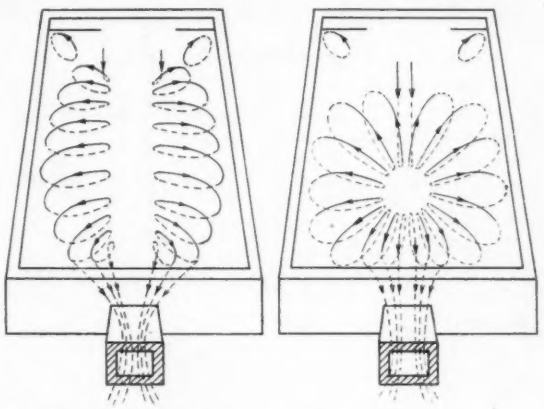
In the refiner there are two completely different conditions in the consideration of sheet glass tanks and throat type tanks. In the sheet glass tank there is a long refiner in which the glass cools slowly by radiating to the crown and is frequently cooled by water chills over the glass surface. The flow is similar to that in the melter with a forward flow on the unobstructed top surface and a return flow lower down. Temperatures are highest at a point somewhat below the surface since the surface can radiate easily. The hottest level drops steadily throughout the refiner length. The amount of glass flowing forward is several times the pull. In the refiner on a throat type tank, glass from the throat rises fast to a *spring* directly in front of the throat. From here it starts out on the surface radially toward the feeders; however, due to the cooling of the surface, it submerges quickly but still travels radially toward the walls. Here such glass as is not selected by the forehearth throats drops downward and returns either to the *spring* or back through the throat. Thus the glass in this type refiner is vigorously stirred by convection currents while the flow in the sheet glass tanks is kept as streamlined as possible. This stirring of glass in the refiner is not in the best interests of quality glass either for seeds and blisters or homogeneity, but it serves to cool the glass quickly and give high production in a short tank.



Currents (solid lines) radiating from throat in refiner according to Gehlhoff.



Pattern in first part of melter according to Preston. A-B-C Batch Piles. D—Hot Spot



Paths of currents at time of heavy production in the melting end of a glass tank having a throat. Maximum temperature region near filling-on end.

Paths of currents at time of light production in the melting end of a tank having a throat. Maximum temperature region in path of travel.

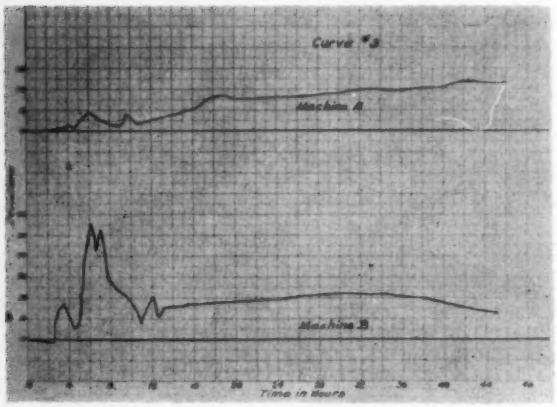
From Gehlhoff

Window Glass Tanks

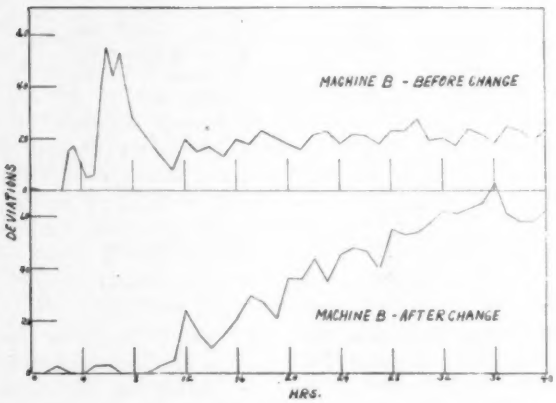
Three window glass tanks on which data have been previously published will be discussed first. These are all large tank furnaces holding from 1,500 to 2,000 tons of glass and having daily pulls from 200 to 300 tons. Two of these were shown in the paper, "Tracing Flow in Glass Tank Furnaces,"[7] while the second of these is compared to the third in the paper, "Effect of a Tank Design Change on Glass Flow."[4] Tracer curves for a centrally located machine as close as any to the melter are shown in Graphs 1 and 2. Other machines for the second and third tanks discussed are shown in Graph 3.

There is not much which can be said about the section of the tank where the batch is melting out. The first and third tanks used a Frasier-Simplex blanket type of batch charger, while the second was charged by the old method of dumping a charge from a car and pushing it in by hand. The blanket method appears to smooth out some of the jumpy nature of the tracers as shown by comparing the top and bottom curves of Graph 3.

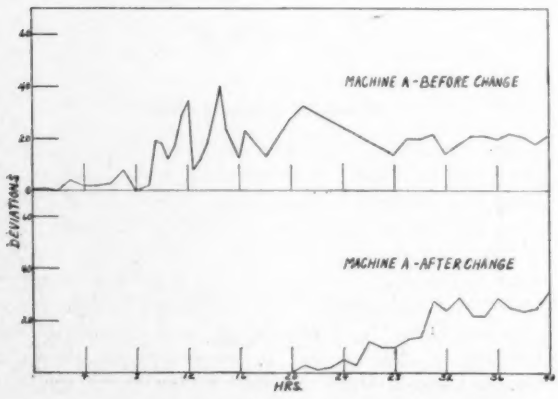
These tanks can be used to illustrate the types of flow called *displacement* and *surface*. As mentioned previously, there is no sharp dividing line and each tank shows some characteristics of each type. The first of these tanks illustrated the displacement type of flow. The first curve in Graph 1 is typical of this type. Here we have a relatively smooth increase in tracer concentration to a maximum which has not even been reached in the 46-hour period shown. The integrated curve for this furnace shown in Graph 4 is also typical with a sloping foot on the curve during the first few hours and a gradual increase with no twisting of the curve as the tracer is used up. Graph 5 shows the integrated curves for the second and third tanks. The second tank, labeled "A" shows surface flow; the third is a displacement type.



Graph 1



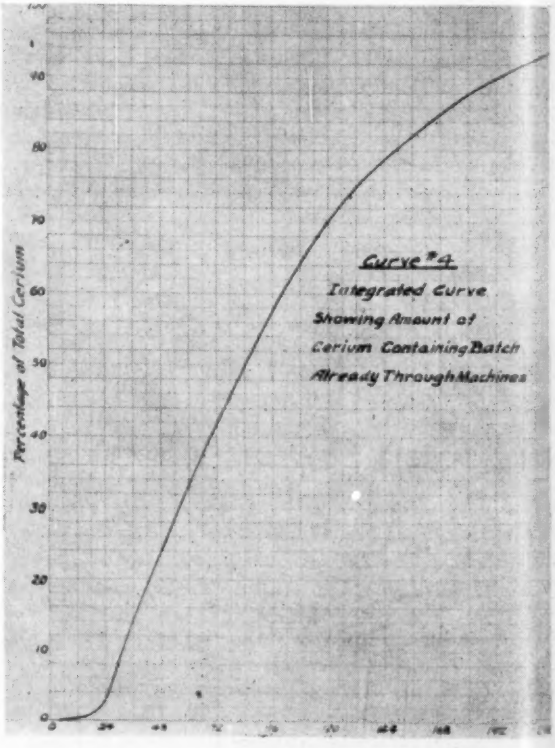
Graph 2



Graph 3

To further show the displacement flow concept, there follow some illustrative figures used in an unpublished paper by Bishop and Staples[8] which was presented to the Glass Division in 1946, entitled "Furnace Density Surveys". A sampling device shown in Figure 1 was used to secure samples of glass at various depths in the melting section as shown in Figure 2. Samples were taken during a deliberate batch change causing a change in glass density. The density of the glass from the forming machine each day is compared with the density at each depth in Graph 6. In Graph 7 these curves have been smoothed by averaging three days' results. The similarity between the densities at various depths and ware is marked.

The second tank shows a prominent surface flow. This may best be seen in Graph 1. This tank is outlined in Figure 3 and labeled *before change*. On the graph evidence of tracer appears in about three hours. This tank has a distance from charger to machine of close to 150 feet, so a rapid flow must take place. The high peaks at about six hours' time reach concentration of tracer high-



Graph 4

er than any which follows. Another machine on this same tank is represented by *before change* in Graph 3. This machine is still further from the batch charger.

As can be seen on Figure 3, this tank had a narrow neck between melter and refiner and four feet in the neck and canals. After the change, the melter and refiner were separated only by a shadow wall and the tank was four feet deep up to the canals. As mentioned previously, a blanket batch charger is on the revised tank while the old tank used the batch pile system. The net effect of these changes is shown on Graphs 2 and 3. Graph 2 shows that the fast surface flow has been reduced and nearly eliminated. The times of first arrival on Graph 2 are three hours and 11 hours, while on the machine shown in Graph 3 they are seven hours and 24 hours. In calculating these times, deviations of less than five are not considered. This reduction in flow velocity can be almost completely explained by the reduction in furnace depth. The change in type of flow is caused by the elimination of the narrow necks. The change in flow time follows the change in depth. Some improvement in the smoothness of the curves is due to the change in charging methods.

Two further graphs illustrate the last or revised tank. Graph 8 is made from the second curve on Graph 2 by taking three-hour averages. Each point on this curve represents the average of the tracer concentration for the hour shown, the hour before and the following hours. The cycling at about 10-hour intervals is interpreted as showing recirculation of tracer containing glass from the working end to the hot spot and back to the working end.

On Graph 9 three machines on this revised tank are plotted over a period of nearly two weeks. Each point represents an average of eight hourly values. Three features should be noted. First, the peak concentration is not reached for about three days and considerable tracer remains after two weeks. Second, the points marked D represent period when the machine is not operating, but no effect on the flow is found. Third, the points plotted lie

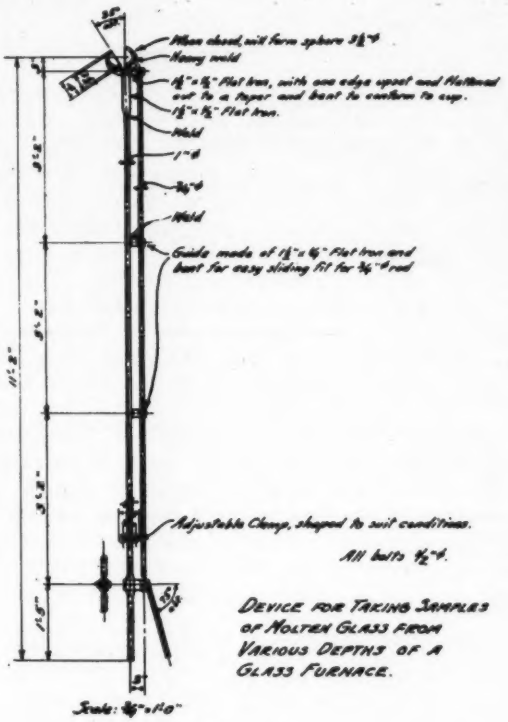

Mass closed, will form sphere 3½"ø
Heavy weld
1½" x ½" Flat iron, with one edge upset and flattened out to a taper and bent to conform to cup.
1½" x ½" Flat iron.
Weld
1" ø
¾" ø
Weld
Guide made of 1½" x ¼" Flat iron and bent for easy sliding fit for ¾" ø rod
Adjustable Clamp, shaped to suit conditions.
All bolts ½" ø.
DEVICE FOR TAKING SAMPLES OF MOLTEN GLASS FROM VARIOUS DEPTHS OF A GLASS FURNACE.
Scale: ½" = 1'0"

Figure 1

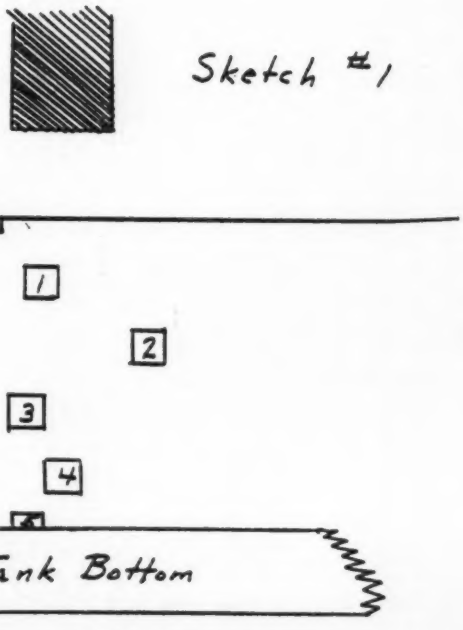
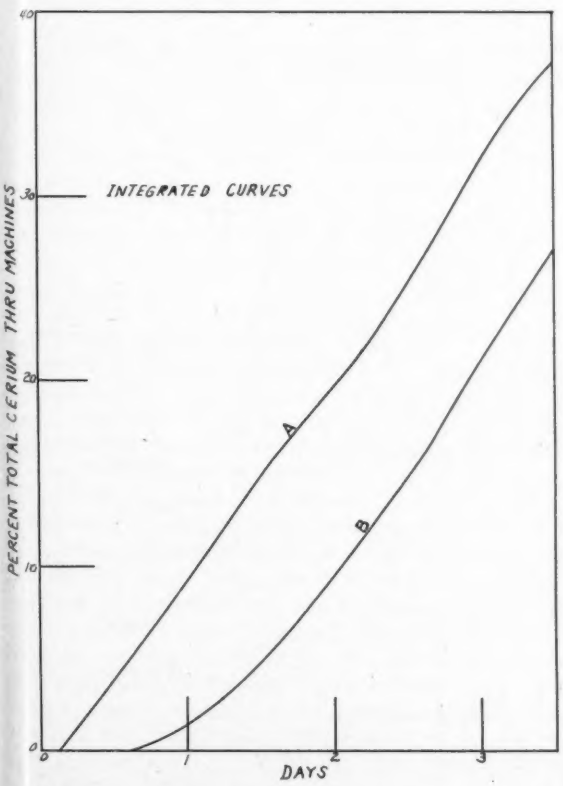


Figure 2



Graph 5

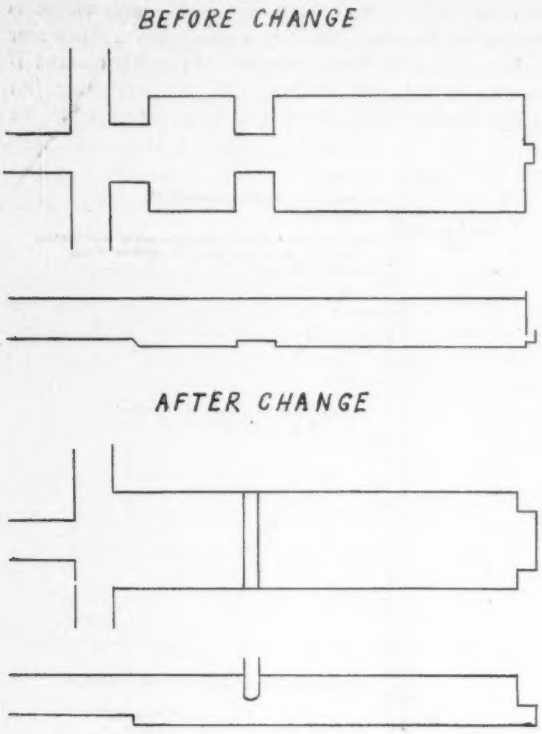
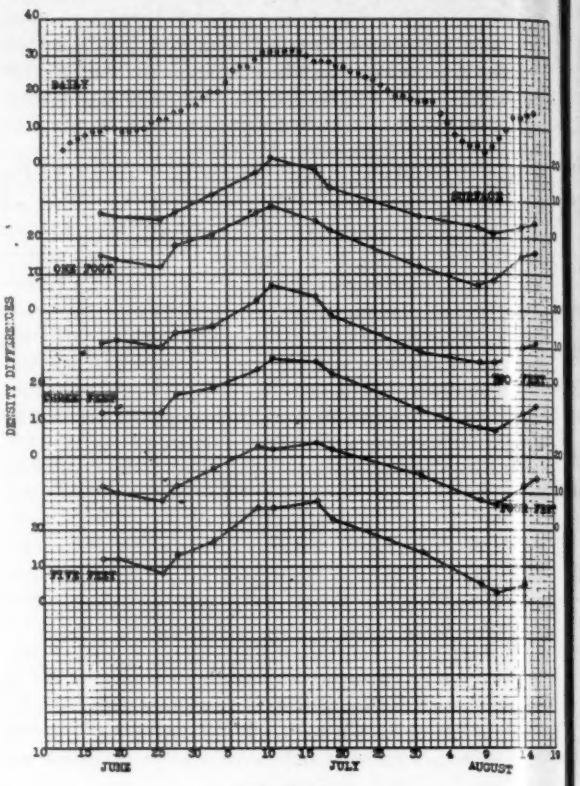
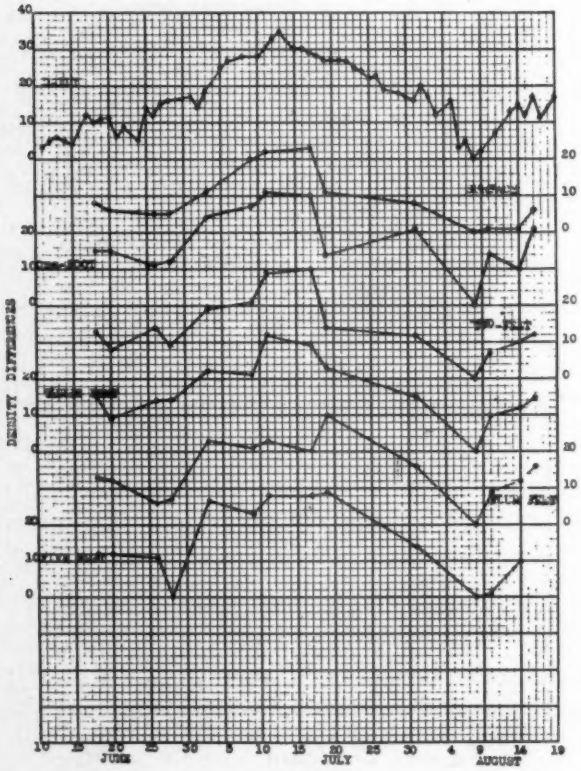


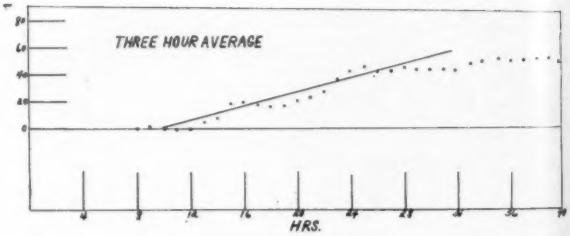
Figure 3



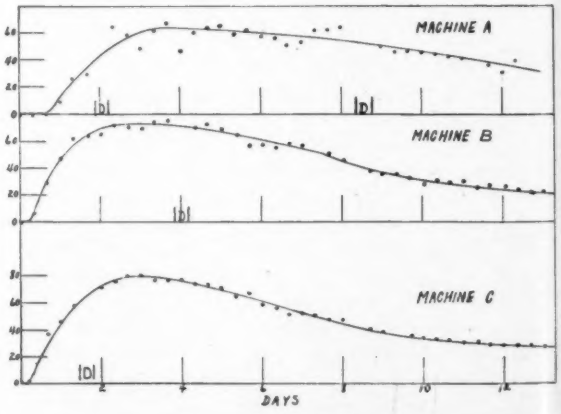
Graph 7



Graph 6



Graph 8



Graph 9

(*Continued on page 99*)

Atomistic Approach to the Adhesion to Glass

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Abstract

In a recent publication (R. Gomer and C. S. Smith, "Structure and Properties of Solid Surfaces," The University of Chicago Press, 1953) W. A. Weyl discusses several methods which can lower the surface free energy of solids. He develops a new concept of the principles which are responsible for the aggregation of atoms and ions to form solids. This concept is used in this paper to classify the different mechanisms of adhesion. Such a classification is presented and several factors are discussed which play a prominent role in adhesion phenomena, for example, the effect of long range order and of hydrostatic pressure. Using the glass surface as an example, the writer will point out how these different mechanisms operate in adhesion between glass and metals, and ionic and molecular compounds. The tentative division of mechanisms of adhesion are, metal to metal bonds, adhesion by induced image forces, epitaxy or oriented overgrowth, mutual sharing of anions and proton transfer reactions resulting in electrical attraction.

Introduction

An atomistic approach to adhesion has to be based on the atomic structure of the phases involved (solids and liquids), on their chemical compositions, and on the nature of the binding forces which are established between the adhering surfaces. The atomistic approach supplements the approach which treats matter as continua characterized by properties such as surface roughness, surface tension and tensile strength. The main difficulty of the atomistic approach to adhesion results from an incomplete knowledge of the structure of surfaces. It is well established that even for the simplest solid, e.g., a NaCl crystal, the geometry of the surface is not the same as that of the interior. X-ray diffraction permits measurement of the interatomic distances in the interior of a crystal with great precision, but when this knowledge concerning the structure of a crystal is extended to its surface, the results are less certain.

In the last few years W. A. Weyl[5,18] has developed a crystal chemical concept of the atomic structure of surfaces, which explains why and how a surface differs from the structure of the bulk. Based on the extreme ionic viewpoint as it is widely used in crystal chemistry and on the Fajans' concept of chemical binding forces, Weyl developed a concept of the atomic structure of solid surfaces that is in good agreement with the facts and which made it possible to predict some unusual chemical reactions that could be verified by experiment.

Presented at a Symposium on Adhesion before the American Chemical Society Meeting, April, 1955 at Cincinnati, Ohio.

Weyl's approach to solid state chemistry centers around two basic principles which seem to govern the structure and the chemical reactivity of the condensed phases, liquids and solids, namely, electroneutrality in the smallest possible volume and screening of positive cores by an environment of electrons or anions. The first principle is known as the electrostatic valence rule described by L. Pauling[14]. Sodium has the valence one, but in solid NaCl each sodium ion is surrounded in space by six equidistant Cl^- ions and its binding forces are the same with respect to all six Cl^- ions. The geometry of crystals is such that it leads to a neutralization of the charges of the ions in the smallest possible volume.

The second principle was derived by Weyl in order to account for the facts that most elements are solids and that the only atoms which can be found under normal conditions (normal temperature and atmospheric pressure) are the atoms of the rare or noble gases. In spite of the wide use of the concepts of atoms as the constituents of all matter, our knowledge of these particles is extremely meager even for such common elements as carbon, sulfur, and phosphorus. Even at high temperatures, e.g., 2000° C, these elements form solid aggregates or molecules. Weyl postulated that only in the rare gases are the nuclei sufficiently "screened" by the number of electrons that compensate for the excess positive charges of the cores. All other atoms tend to improve the screening of their nuclei at ordinary temperatures. Nitrogen atoms do so by forming N_2 molecules, i.e., particles in which two N^{5+} nuclei are screened by ten electrons moving in molecular orbits.

The simplest and one of the most efficient ways to screen nuclei seems to be the formation of metals. Metals consist of an orderly array of cations which are screened by the "electron gas" surrounding each core in a highly symmetrical fashion. Most elements are metals and many of the remaining elements (selenium) and compounds (Pbs, VO, UO_2) imitate metallicity. The characteristic feature of metals is the high mobility of their anions, the free electrons.

A third method of improving the screening of cores consists of the formation of anions and cations by electron transfer and the arrangement of these particles in infinitely extending arrays in which each cation is surrounded by anions. Among these solids there is one group which deserves special attention, namely those compounds which contain H^+ ions, i.e., protons as cations. The proton is the only cation which does not contain electrons. Its screening demand differs from those of other cations, because a proton can either penetrate into the electron cloud of an anion or it can be screened like other cations by an environment of anions.

The Surface Energy of Solids

The surface energy of a solid is defined as that energy necessary to increase the surface area of a system. There are no experimental methods at the present time which allow the precise measurement of the surface energy of a solid.

From an atomistic viewpoint the surface energy is the result of the electrical forces which emanate from surface ions because those ions which are located in the surface are not completely surrounded by ions of the opposite charge. The surface energy of a solid depends upon the nature of its ions and is influenced by their field strengths, i.e., their size, charge and the deformability of their electron clouds.

Adhesion to the surface of a solid will occur whenever the surface free energy of the solid and that of the adhering phase can be lowered. Five methods for lowering the surface energy will be discussed in this section.

Role of Electronic Polarization of Surface Ions. In order to appreciate the role which electronic polarization plays in lowering the surface energy of a solid surface, consider the cube face of a freshly fractured MgO crystal. The cube face of this crystal represents an array of cations and anions which are incompletely coordinated. If corners and edges are ignored, each ion has the coordination five instead of six. These surface ions are part of the asymmetrical units

. . . . anion - cation - space
. . . cation - anion - space

The electrical distribution around the surface ions cannot remain as it was when the ions were in the interior of the unfractured solid because of the strong force fields created by these asymmetrical electron environments. The mechanism of electronic polarization under these conditions is shown in Figure 1, A and B. The forces emanating from the anions are strongly decreased by a deformation of the electron clouds or a polarization of the anions which induces a dipole and thus decreases the negative force field directed toward the surface of the crystal. This is represented by a decrease in the length of the arrows from the anion toward space in Figure 1, B. Without a partner at the opposite side, the electron clouds of the anions are pulled over toward the cation. High electron densities around an ion are represented, in Figure 1, B, by a shaded area.

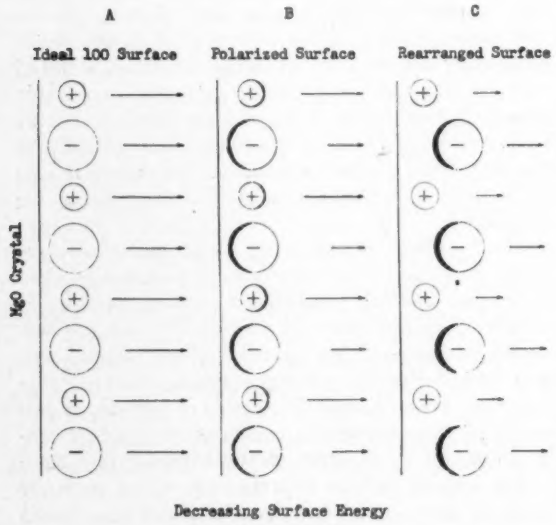


Figure 1

In solids with cations of fairly low polarizabilities such as MgO, polarization of the cations in the unit (. . . . anion - cation - space) may be neglected.

The primary effect of the different polarizabilities of the ions at the surface of a solid of this type is one which changes a checkered surface emanating positive and negative fields of equal intensity into one emanating strong positive but weaker negative electrical fields. This state of affairs is indicated by the length of the arrows in Figure 1, A and B.

It is well to remember that electronic polarization, an instantaneous process, is not completed in one layer of ions but tapers off through many layers into the normal crystal lattice if sufficient volume of the solid is available.

This gradual change in electron distribution around the ions is a depth action.

Electronic polarization for lowering the surface energy of a solid depends on the polarizability of all the ions in the surface. It is high for cations like Hg^{2+}, Pb^{2+} and anions like Br^-, I^- and low for cations like Si^{4+}, Al^{3+} and anions like F^-. The degree of polarization for any particular ion depends on its environment and is not necessarily constant for all situations.

Nucleation in supersaturated solution may be given as an example of the role of electronic polarization in determining the surface energies of crystal nuclei. An aqueous solution of CaF_2 must be 500 per cent supersaturated, according to A. T. Jensen[7], in order to form crystals. The low polarizability of the Ca^{++} and F^- ions causes this substance to have a high surface energy. An aqueous solution of HgI_2, Ag_2S, or PbI_2 cannot be supersaturated because of the low surface energy of these crystals in which both ions have high polarizabilities.

Structural Changes in Surface. In addition to electronic poralization of the surface ions, the freshly formed surface of a solid can lower its free energy by a geometrical rearrangement which leads to better screening of the surface cations and a weakening of the emanating positive forces. As the screening of a Mg^{2+} ion is much more important than that of an O^{2-} ion in MgO, a surface structure may result in which the extreme outer layer contains only O^{2-} anions. This is particularly true if the cation is small in size, has low polarizability and a high charge like Mg^{2+}, Al^{3+} or Si^{4+}.

This geometrical rearrangement is pictured schematically in the transition from B to C in Figure 1. The cations retreat from the surface in an attempt to improve their screening, thus forcing the anions to the surface. The extent to which the surface structure changes depends on the charge and size of the ions. Such a deformed surface may be described as having an electric double layer. It is obvious that this structural change must taper off and has a depth action.

The fluidization of freshly formed MgO crystals when $Mg(OH)_2$ is dehydrated, demonstrates the lowering of surface energy by a structural change which produces an

electrical double layer in the surface of the solid. The failure of corundum and other hard minerals to induce oriented overgrowths provides additional evidence for the non-existence of a checkered electric field and for a structural change in the surface ions.

Development of Excess Electrical Charges. Anions are larger and more polarizable than cations in general. Thus, the surface energy of a solid is lowest when the extreme outer layer consists of deformed anions. All the cations are more or less screened by the anions. If this outer layer consists entirely of anions a nonstoichiometric composition usually exists in the solid and leads to an excess of negative charges. Excess charges of particles play an important role in the stability of colloids.

This phenomenon is illustrated in the precipitation of AgI from aqueous solutions. If equal molar quantities of $AgNO_3$ and KI are allowed to react, minute crystals of AgI are formed which contain a deficiency of Ag^+ ions and have an excess negative charge. This fact has been demonstrated in experiments by E. J. W. Verwey and H. R. Kruyt[17]. In order to produce electrically neutral crystals of AgI, an excess of silver nitrate must be used so that the ratio of Ag^+ ions to I^- in the supernant liquid is approximately 1000 to 1.

Whenever a solid contains ions of widely different polarizabilities and its anion-to-cation ratio is low, so that it does not permit satisfactory screening of the cations, the formation of charged particles may occur. The liquid-solid system has lowered its free energy by decreasing the surface energy of the solid phase.

Adhesion Forces of Small Particles, Fibers, and Thin Films. E. A. Hauser[6] has stated that thin films and fibers may exhibit colloidal properties because it is sufficient for this purpose to reach the colloidal size in one or two dimensions respectively. Many colloidal properties are the result of the high surface energy of solids in finely subdivided form.

If the process of lowering the surface energy of a solid by structural changes requires a certain depth, it is apparent that this process can be effective only in particles which are sufficiently thick to permit the distorted surface to taper off into the undistorted structure of the solid. Solids which are small in either one, two, or three dimensions, e.g., thin films, fine fibers, or small particles, have surface energies which are very high because in these systems the depth is lacking for a transition. For this reason the surface energy is much higher than the value derived from the surface area.

Adhesion forces of thin films have been determined as a function of their thickness. H. P. Meissner[13] found that the gliding friction increases rapidly for unsupported films of gold and other materials when they become thinner than 0.25 microns. The gliding friction or adhesion of a metal point to a thin film of gold could be decreased if a drop of water were brought onto the backside of the film. Vacuum deposition of films on glass by evaporation techniques show a change in surface forces with thickness of the deposited film. F. K. Truby and A. F. Turner[16] were able to build up adhering films of MgF_2 on glass to a thickness of one micron, but not more. For each substance, e.g., MgF_2, ZnS, etc., a critical thickness was found below which they adhere and above which they flake off.

The surface energy of thin fibers produces strong adhesive forces, and Weyl attributes the superior properties of asbestos in brake linings to the dimensions of the fibers of the asbestos rather than to its chemical composition. For the same reasons he assumes that the constancy of fiber diameter in drawn glass is partly the result of an increased viscosity with decreased diameter.

It is known that in milling operations the energy necessary for increasing the surface area by a certain amount increases drastically when the particle size becomes very small. G. T. Beilby[1] has found that particles of gold and silver will stick to glass when the diameters are less than 0.113 and 0.165 millimeters respectively.

Aging of Surfaces. The surface energy of solids can be decreased by adsorption of polarizable foreign substances, molecules, dipoles, or charged particles, especially anions. This method of lowering surface energy, aging of a pristine surface, becomes important for solids which contain cations of low polarizability and which have a low anion to cation ratio, e.g., SiO_2.

A clean dry glass surface shortly after fracture consists of a layer of OH^- ions because there is sufficient water in the atmosphere to be attracted and used to saturate the valence forces which become available through fracture. The hydrated glass surface is hydrophilic and water, alcohol, sulfuric acid, or other liquids having OH^- groups adhere to it. The role which the OH^- groups play in adhesion to the glass surface can be demonstrated by a simple experiment. Concentrated H_2SO_4 containing a small amount of $K_2Cr_2O_7$ is heated in a test tube. The chromate oxidizes the organic impurities at the surface of the glass and thus produces a clean surface containing only OH^- ions. The acid wets completely the surface of the glass. If a trace of a fluoride is added to the acid, the OH^- groups at the surface of the glass is replaced by F^- ions:

$$\equiv Si—OH + HF = \equiv SiF + H_2O$$

This reaction proceeds to completion because the water formed is removed by the concentrated H_2SO_4. One will observe that the sulfuric acid no longer adheres to the surface of the glass but forms little droplets. The F^- replaced the OH^- ions at the glass surface. F^- is able to screen the Si^{4+} ion, but it is not likely to accept a proton from a H_2SO_4 molecule, a process which would improve the screening of the S^{6+} ion and thus, improve the adhesion.

Exhaling against a cold glass, as a rule, does not produce a uniform water film but causes the moisture to condense in little droplets on the surface because of the unavoidable greasy matter attracted from the surroundings and firmly held by the glass surface.

A Classification of the Different Mechanisms of Adhesion

The principle of the screening of cores by an environment of electrons or of anions suggests a tentative classification of the possible mechanisms of adhesion between different kinds of solids according to their atomic structure. A brief review of Weyl's ideas concerning the mechanisms which can lower the surface energy of solids has been given. Now a classification of adhesion mechanisms will be proposed.

Metal to Metal Bonds. The adhesion of metal surfaces is closely related to their reactivity in the solid state. The reactivity of solid metals was well established long before the possibility was accepted that oxides or salts can react in the solid state. Those who had an opportunity to work with platinum at red glow temperatures must have noticed its "stickiness."

The surface of most metals under ordinary conditions is coated with a thin layer of oxides. Oxygen from the atmosphere improves the screening of the surface cations of the metal. At high temperatures this platinum oxide film dissociates and the mobile electron clouds of two adjacent platinum surfaces can continue the crystal lattice with its inherent strength. This type of adhesion is identical with the sintering of metals.

Induced Image Forces. If NaCl or Na_2CO_3 is fused in a platinum crucible, there is little chance of removing the cooled melt intact from the crucible. This strong adhesion between these otherwise incompatible media, the ionic salts NaCl or Na_2CO_3 and the noble metal platinum, can be explained by "induced image forces."

The surface of the sodium chloride has a potential field which polarizes the metal surface and produces image forces in the highly mobile electron clouds of the metal. Each Na^+ ion of the NaCl surface is attracted to the metal by a spot with high electron density, which it has induced by its own positive force field. Opposite each Cl^- ion a spot of low electron density exists in the metal.

E. C. Marboe, W. D. Smiley, and W. A. Weyl[12] showed that a small amount of RbBr added to the fused NaCl prevents adhesion. The cooled melt can be removed easily in one piece from the platinum crucible. The highly polarizable ions of RbBr and their weak fields cause them to accumulate at the salt to metal interface. These ions cannot induce image forces of sufficient strength in the platinum for adhesion. For this reason RbBr alone does not adhere to the crucible either.

Epitaxy. A solid may lower its surface free energy by continuing, so to speak, its structure with compatible building units of a second solid, thus decreasing its surface area. This is the simplest case of adhesion between ionic solids and is called "epitaxy" or "oriented overgrowth." An example of this type of adhesion is the oriented overgrowth of KI on the surface of freshly cleaved mica.

Crystals containing cations of high field strength, such as corundum, cannot show this type of adhesion because they do not have checkered force fields at their surfaces as was pointed out earlier. Oriented overgrowth is not induced by minerals with a hardness on Moh's scale greater than four.

Adhesion of this type is of limited practical value because the surface of the solid must be clean and must have a plus-minus force field.

Sharing of Anions. Weyl uses the compounds SF_6, a rather inert gas, and SO_3, a very reactive molecule, in order to illustrate the role which the anion to cation ratio plays in the screening of cations. The S^{6+} ion of the SF_6 molecule is well screened by the number of F^- ions needed to neutralize its excess charge. This is not the case for SO_3 because the three O^{2-} ions which neutralize the charge of S^{6+} are not sufficient to completely surround or screen the central cation. SO_3 can react with H_2O or basic oxides to form $(SO_4)^{2-}$ groups or it can polymerize to an asbestos-like modification which consists of S^{6+} ions screened by four O^{2-} ions some of which are shared between two S^{6+} ions in the following:

$$\begin{array}{ccccccccc} & & & O & & O & & O & \\ - & - & - & O & S & O & S & O & S & O & \text{etc.} \\ & & & O & & O & & O & \end{array}$$

Sulfur trioxide should be an adhesive because it has a tendency to improve its screening by coordinating with other ions. That this is true, is shown by the work of W. H. Kohl[8] who used nascent SO_3 for bonding powdered zinc orthosilicate (a phosphor) to the glass surface of a cathode ray tube. The mechanism of the bond consists of a sharing of OH^- or O^{2-} ions between the glass at one side and the silicate phosphor at the other in the following manner:

$$\begin{array}{ccccccc} & & O & & O & & \\ \text{Glass} & O & S & O & S & O & \text{Zinc Silicate} \\ & & O & & O & & \end{array}$$

The fact that the phosphor could be wiped off the glass surface easily with a cloth indicates that a Si-O-Si bond is not the mechanism which links the glass and phosphor. Such a bond, however, may be established when the glass plus the powder are heated to about 500°C.

W. A. Weyl and E. A. Hauser[21] used the concept of sharing of OH^- ions in order to describe the polymerization of orthosilicic acid monomers.

Adhesion through Proton Transfer Reaction. Compounds containing hydrogen in the form of H^- ions are quite normal with respect to their chemical and physical properties. This is not always true for compounds which contain hydrogen in the form of protons because some compounds are known to have exceptional properties. A theory has been developed by workers like W. M. Latimer and W. H. Rodebush[10] under the name of "hydrogen bonding" to explain these unusual properties. K. Fajans and N. Bauer[4], in order to explain the different behavior of hydrogen compounds, pointed out that a proton could combine with anions by entering their electron clouds. This unique property of the proton may be accounted for by its small size and the absence of electrons. The proton in combination with a large and polarizable anion such as Cl^- leads to a molecule like HCl in which the proton is screened by entering the electron cloud of the anion. Ions with a small electron cloud like F^- ions will not favor this interpenetration and as a result protons in combination with F^- ions behave more like normal cations and require screening by a coordination with anions. The small size of the proton allows it to be completely screened by two anions and it is this kind of binding which leads to $(HF)_x$ polymers which are said to contain hydrogen bonds. Thus it is seen that hydrogen bonding may be expected when the ions to which protons are attached have relatively low polarizability and a relatively small number of electrons. The O^{2-} ion is outstanding for its ability to form hydrogen bonds where its polarizability is low.

(*Continued on page* 94)

Pittsburgh Plate Glass Company's new curved-windshield manufacturing plant at Greensburg, Pennsylvania. At the extreme right, the plant connects with the warehousing area.

PPG's New Specialized Plant and Warehouse at Greensburg, Pa.

Pittsburgh Plate Glass Company recently put into production a new fabricating factory designed for the manufacture of non-current wrap-around windshields. This plant located at Greensburg, Pennsylvania, does not produce plate glass but receives this "raw material" for its fabricating operation from the firm's large plate glass manufacturing operations located elsewhere.

The new facility was conceived and designed specifically for the manufacture of short runs or job lots of curved windshields for earlier model cars. Windshields for automobile models still in production will continue to be manufactured at the Creighton, Pennsylvania, and Crystal City, Missouri, mass production factories.

Bending glass is an old art. However the production procedures involved in bending "twin" sections of glass in a single bending iron while retaining good optical

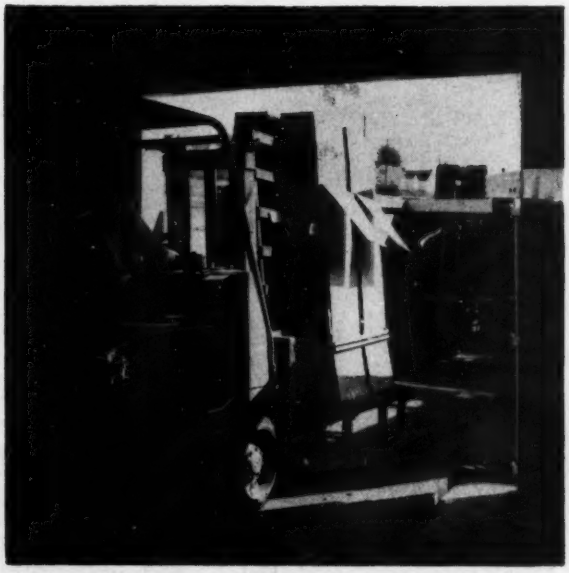
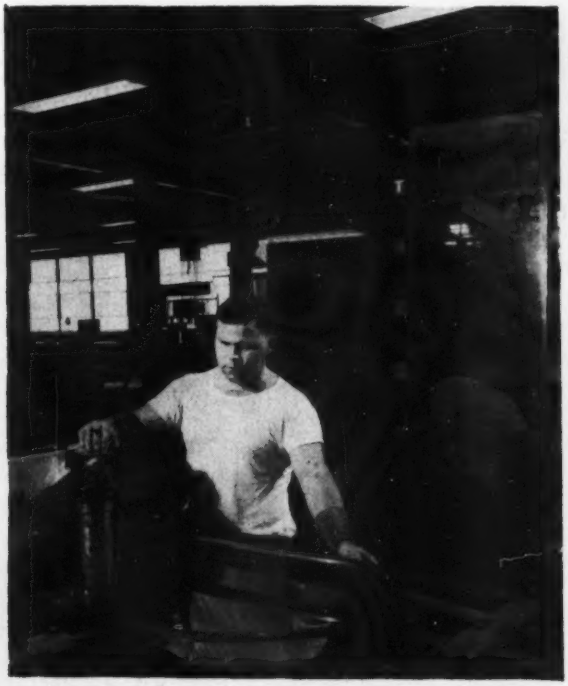


Plate glass sheets are shipped from PPG's plate glass producing plants. Plate glass sheets, on pallets, are unloaded at the Greensburg plant.



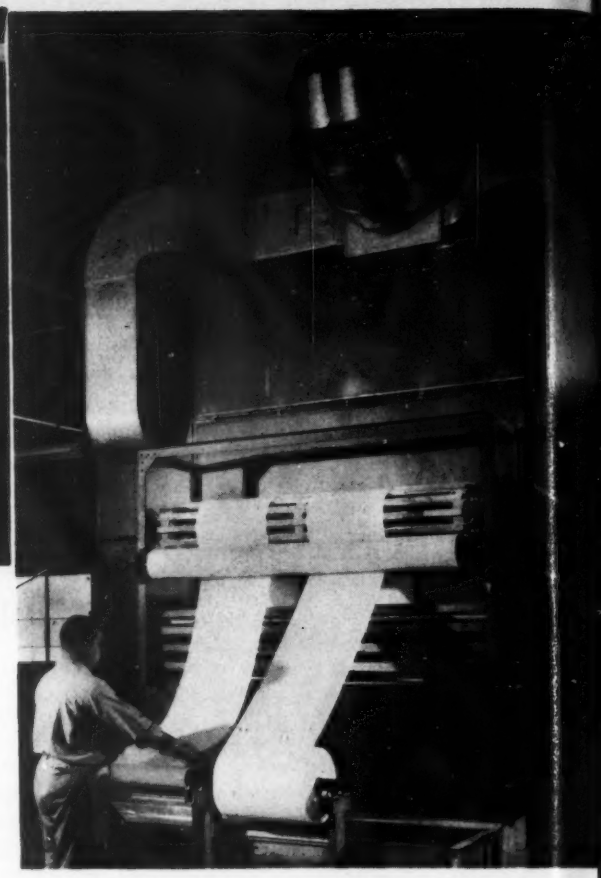
A semi-automatic glass cutter is used to cut the plate glass sheets to exact size and shape of the various windshield patterns. Excess glass trimmed from the edges becomes "cullet" and will be returned to the Creighton plant for use in a new glass batch.

The flat cutting operation is handled by two operators. One cuts the inside sheet and the other trims the outside sheet for the new curved windshield. (The outside sheet is a fraction of an inch larger.) Following this operation, the sheets move through manufacturing steps until the two glass sections are laminated.

qualities in the large area windshields has been a big problem to the industry. Manufacture of massive sized windshields with complex curves is relatively new and a field in which the manufacturer continuously faces new problems with each model change.

The curved windshield, with two lights of glass in the unit, now uses about 10 square feet of plate glass, an increase of about 70 per cent more than the models produced for the market following World War II.

The use of larger curved windshields by the automobile industry has been a substantial factor in the tremendous increase in plate glass demand during the past ten years.

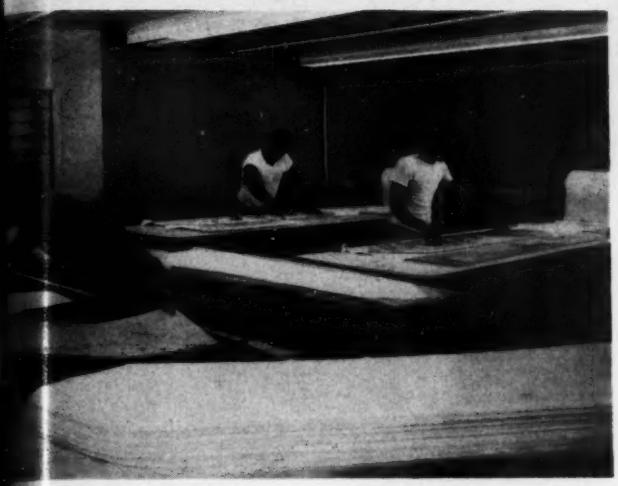


Rolls of plastic are shown being fed through a huge plastic dry properly condition the material for use between the sheets of g The plastic becomes transparent in a later fabrication step.

Pittsburgh Plate reports that during this period, the company has increased its plate glass manufacturing capacity

Excess plastic is trimmed as the glass moves along a conveyor line in this air-conditioned area.

An assembly inspector examines the glass sandwich as it le the assembly room. Rejects for imperfection in the product occ various manufacturing stages.



al view of the plastic cutting room where temperature and idity are rigidly controlled. Here, plastic sheets are cut to rn sizes.

Plastic interlayer is placed sandwich-style on outside sheet as windshield takes form. The complex curves in the wrap-around type windshield are graphically shown here.

by 100 per cent. A substantial additional capacity will be available when the $34,000,000 plate glass producing facility under construction at Cumberland, Maryland, goes into production in about one year.

The very nature of the new Greensburg plant points out a significant evolution in the flat glass industry.

For some years the industry has been undergoing a constant change, from its position as a producer of flat plate glass sheets. That manufacture, of course, is still the industry's primary function but fabrication of specialty products has been constantly increasing, both for the construction and automotive industries.

In addition to the multi-million dollar plant at Greensburg, Pittsburgh Plate Glass Company has converted an existing factory building into a warehouse and distributing depot for curved automobile replacement glass. This warehouse contains about 145,000 square feet of floor space and adjoins the fabricating plant.

The assembled parts are given an oil bath in this autoclave. Here the plastic becomes transparent and the parts are permanently annealed into a curved windshield. Here an operator is shown lowering the rack into the oil bath. Another operator looks on.

An operator is using a felt covered wheel to remove a small surface mark by polishing the external glass.

The machine shop is essential in keeping the plant in operation.

Storage of both the replacement windshields and the large and constantly growing volume of bending irons required in the manufacturing process is becoming a major problem to the industry. The problem of producing and maintaining a stock of replacement parts for all automobiles will continue to increase each time new models reach the market.

The Greensburg manufacturing operation and the company's depot system were conceived to insure an adequate replacement glass distribution system. Pittsburgh Plate distributes its replacement windshields through 15 such depots strategically located across the nation.

A hi-lift operator is handling a large case of curved windshields. Cases vary in weight from 1,000 pounds to 2,800 pounds. Warehousing and distribution have become major problems.

Exterior view of the distributing depot. This was formerly a manufacturing plant but has been completely renovated and adjoins the curved windshield manufacturing building.

Polish Papers of Interest to the Glass Industry: Translations

ROLE OF GLASS WASTE (CULLET) IN POT COMPOSITION

Discussion by Jan Chmielenski in *Szklo i Ceramika* (*Glass and Ceramics*) 6, No. 8, p. 165-168 (1955). The use of an excess of cullet has a negative effect on the quality of glass melt and on the properties of glass products. During the storage a surface layer forms on the glass fragments. It has a different chemical composition from the bulk. The older the cullet the bigger the change in its surface.

Example 1: A pot was filled with glass waste 7 years old. Some sodium carbonate was added. Glass was melted at 1400° C. and thoroughly agitated. Then it was cast on Bicheroux apparatus. The glass plate contained brown veins due to insoluble sulfides present on the surface of glass fragments.

When glass from two sources was used, the difference in coefficients of expansion caused cracking of the glass.

Example 2: A pot in which cryolite glass was previously melted, was filled with fluorosilicate glass waste. The batch was melted at 1400° C, stirred and cast on the Bicheroux apparatus. In the end part of the glass plate the separated cryolite glass could be identified.

Example 3: A pot used for making mirror glass was filled with glass waste containing 48 per cent PbO. As in the example above some mirror glass got into the glass plate. The layers did not separate but were visible.

Addition of sufficient sodium carbonate is essential. Gases evolved from decomposition of carbonate stir the melt and the surface is activated increasing the diffusion.

DETERMINATION OF IRON OXIDE AND GLASS RAW MATERIALS

Jerzy Borkiewicz and Marian Chrzesczyk in *Szklo i Ceramika* (*Glass and Ceramics*) 6, No. 8, p. 182-187 (1955), review some methods of determination of small amounts of iron (below 0.1 per cent) in glass and raw materials. A new method of analysis by using Ion Exchange resin containing phosphate groups and a quick volumetric method are being developed. In the latter, silicates are dissolved in cold $HF + H_2SO_4$ and not vaporized, and the iron is determined by titration with thioglycolic acid.

The authors determined iron by a colorimetric method using potassium thiocyanate and two colorimeters: Dubosq and Visomat. The latter measures the light transmission through the solution by means of a photo-electric cell. The concentrations are then obtained from a calibration curve.

Measurements of solutions showed that the error was considerable (9.3-15 per cent) when a solution of 0.002 mg Fe_2O_3 per cc. was used. This corresponded to 0.05 per cent Fe_2O_3 in the sample of glass.

Using these two colorimeters, the amount of iron in several samples of glass and sand was determined. The results are shown in Table I.

Table I

Sample	Amount of Fe_2O_3 in % determined with Dubosq colorimeter	Amount of Fe_2O_3 in % determined with Visomat colorimeter	Difference in %
Bottle glass	0.60	0.59	0.01
	0.61	0.59	0.02
Dolomite	0.32	0.30	0.02
	0.32	0.31	0.01
Plate glass	0.28	0.29	0.01
	0.29	0.28	0.01
Glass tubes	0.20	0.21	0.01
	0.21	0.21	..
Rods	0.060	0.050	0.01
	0.070	0.050	0.02
Hohenbock sand ..	0.022	0.020	0.002
	0.020	0.019	0.001

THERMAL INSULATION OF GLASS FURNACES

Jerzy Borkiewicz in *Szklo i Ceramika* (*Glass and Ceramics*) 6 No. 9, p. 194-197, 1955, discusses thermal insulation of glass furnaces results in 15-20 per cent saving in fuel.

Following formulas are suggested for preparing insulating materials for the outside of the furnace walls.

1.	Chamotte powder 0.75-1.25 grain size.....	40%
	Roasted silica powder.....	40%
	Asbestos	10%
	Water glass	10%
2.	Fire clay.....	15%
	Quartz sand	50%
	Bauxite	35%
3.	Roasted powdered silica.....	60%
	Asbestos or rock wool.....	40%

The materials can be mixed with water or with solution of water glass. After proper heavy consistency is obtained, and the furnace wall is properly cleaned, the paste is put on together with a metal screen to increase its mechanical strength.

A table is given of insulating components for the inside walls of glass furnaces.

Table II

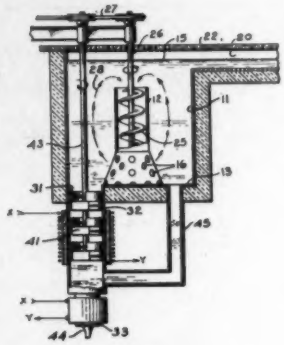
Insulation Components	Chromite	Chromite Magnesite	Clay	Corundum Kianite
Chromite	90-95	50	..	..
Magnesite ...	..	40	..	..
Clay	..	..	80	..
Corundum ...	..	..	..	84
Kianite	..	..	..	10
Clay Czasowjar	5-10	10	20	6

(*Continued on page* 104)

Inventions and Inventors

Feeding and Forming

Glass Blender. Fig. 1. Patent No. 2,716,023. Filed March 23, 1953. Issued August 23, 1955. One sheet of drawings. Assigned to Corning Glass Works, by Robert C. Cleveland.



The present invention relates to the conditioning of glass for the production of relatively large or massive glass objects which are not only substantially cord-free but whose individual index of refraction varies throughout within a very narrow range and it is particularly directed to the production of such high-quality glass objects on a continuous basis.

In the continuous melting of glass the glass stream flowing through the forehearth varies in refractive index both longitudinally and transversely. Longitudinal variations generally result from changes in the batch; transverse variations generally result from volatilization of molten glass constituents and from corrosion or erosion of the melting-container refractories and evidence themselves in the form of cords or striae.

The present invention provides an arrangement whereby blending and stirring can be most effectively accomplished.

Referring to Fig. 1, a screw-type impeller or pump 25 projecting through cover 22 into the interior of stack 12 is adapted for rotation by means of a belt 27 to effect rapid circulation of molten glass within chamber 11. Advantageously impeller 25 is so rotated that the body of molten glass is circulated in the general manner indicated by the dotted arrows, 28. The clearance or coupling between impeller 25 and circular stack 12 is very conveniently such, that some slippage of molten glass over the peripheral edge of the impeller screw can take place.

Depending from an outlet 31 in the bottom 13 of chamber 11 is a cylindrical housing 32 having a volume considerably less than that of chamber 11. Mounted within cylindrical housing 32 on a shaft 43 projecting down through cover 22 and chamber 11 is a stirrer 41. As indicated, shaft 43 is also rotated by belt 27 but preferably in the opposite direction from shaft 26 in order to minimize surface disturbances. At its other end housing 32 is provided with a depending outlet tube 33 for feeding the blended and stirred glass 44 in accordance with the casting procedure.

There were six claims and five references cited in this patent. 2,020,143, Haub, Nov. 5, 1935; 2,515,478, Tooley et al., July 18, 1950; 2,569,459, De Voe, Oct. 2, 1951; 2,641,454, Labino, June 9, 1953; and 711,976, France, July 8, 1931.

Apparatus and Method of Continuously Forming Ribbon of Glass. Fig. 2. Patent No. 2,717,474. Filed November 3, 1953. Issued September 13, 1955. Two sheets of drawings. Assigned to Pilkington Brothers Limited, by Richard Barradell-Smith.

This invention relates to the manufacture of flat glass in continuous ribbon form.

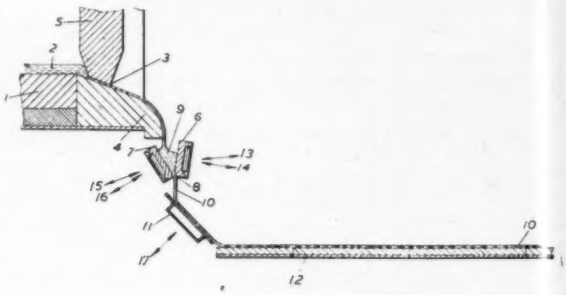


Fig. 2

In Figure 2 is illustrated canal 1 constraining a flow of molten glass 2 from a melting tank (not shown). The canal is provided with an outflow orifice 3 through which the molten glass is discharged over the lip of the spout 4. The glass flowing over the spout 4 falls under gravity into a virtual funnel formed immediately below the lip of the spout between two pool-forming plates 6 and 7 which constitute front and rear walls to a funnel and converge downwardly to a narrow discharge die 8 at the bottom. The size of the die 8 is such, in relation to the size of the outflow orifice 3, that a pool 9 of molten glass of substantially constant volume is formed in the funnel between the downwardly converging forming plates 6 and 7. From the die 8 the glass flows as a ribbon 10 of the desired thickness and passes on to an inclined plate 11 and thence on to a plane support 12 along which the glass is passed to an annealing lehr.

Forming plates 6 and 7 are continuously vibrated, by an electromagnet. This vibration of the plates is in a general direction towards and away from each other and is at a suitably high rate. Thus the axis of vibration of the plate 6 may be anywhere between the limits indicated by the double arrow 13 and 14, while that of the plate 7 is anywhere within the range 15, 16; and a suitable rate of vibration is one hundred oscilations per second. Similarly, the plate 11 may be vibrated along the axis 17. Thus the glass emerging from the die has "fire finished" surfaces.

The present invention, therefore, differs from prior proposals by the employment of the pool of substantially constant volume and the formation of the short die which is fed from the pool. By limiting the size of the pool to that which produces a constant flow to the die, the area over which the glass has to travel to the die is minimized, and the die being as short as possible the heat exchange in the area of the die is minimized. Accordingly, the loss of heat in that volume of the glass

where the area of the surface is greatest in relation to its volume, is minimized. Thus the glass emerges in sized condition as low viscosity glass.

There were 4 claims and 3 references cited in this patent. 1,469,383, Crowley, Oct. 2, 1923; 1,623,051, Fraser, Apr. 5, 1927; and 2,539,398, Bowes, Jan. 30, 1951.

Glass Compositions

Light Reflectors and Glass Bead Elements. Fig. 3. Patent No. 2,713,286. Filed October 22, 1949. Issued July 19, 1955. One sheet of drawings. Assigned to Minnesota Mining & Manufacturing Company by Nelson W. Taylor.

This invention relates to an improvement in reflex light reflectors.

Road signs and markers of the reflex type have greater visibility at night than do ordinary signs and markers, to the occupants of an approaching vehicle, because less of the reflected light is dissipated outside of the field of viewing, the reflected light being concentrated in a narrow cone which automatically returns toward the headlights and occupants of the vehicle.

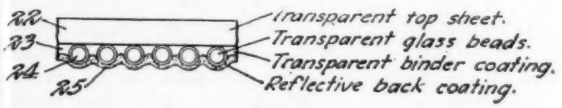


Fig. 3

A particularly advantageous type of structure is that described in connection with Fig. 3, wherein the sphere-lens elements are in direct contact with and partially embedded in an underlying reflective binder layer (which may be coated upon a base or backing). In order to secure maximum reflection brilliancy with this type of reflector, the effective refractive index of the sphere-lens elements should be about 1.9 times the refractive index of the overlying transparent coating. Transparent top coatings made from commercially available and suitable compositions have a reflective index of the order of 1.5, this means that the sphere-lens elements should have an effective refractive index of the order of 2.9. The desired effective refractive index is substantially higher than that of diamonds (i.e. higher than 2.4).

Use is made of transparent glass beads which have a transparent non-porous glass core of high refractive index surrounded by an integral concentric porous solid surface layer.

A suitable porous surface layer can be formed by a chemical leaching treatment of the glass beads.

A preferred glass composition is one consisting of 29.6% of Bi_2O_3, 67.7% of PbO, 1.4% of B_2O_3, and 1.4% of P_2O_5. Glass beads formed thereof can be leached in dilute nitric acid solution to provide a porous surface layer of necessary thickness to cause the effective refractive index of the treated beads to be approximately 2.9 or even higher.

These glass compositions are low-melting and melt to a very free-flowing state. Glass beads in the desired diameter range of 1 to 10 mils or smaller can be made by fusing particles of glass cullet which are blown or dropped through a high temperature flame or a radiant heating zone to soften them sufficiently to form transparent spherecles by the action of surface tension while moving through air, followed by rapid cooling to harden the beads without devitrification. The cullet can be made by quenching a stream of molten glass in water.

There were 4 claims and 13 references cited in this patent. Re. 19,070, Chretien, Feb. 6, 1934; 1,044,135, Buechner, Nov. 12, 1912; 2,113,380, Nichols, Apr. 5, 1938; 2,348,704, Adams, May 16, 1944; 2,379,702, Gebhard, July 2, 1945; 2,379,741, Palmquist, July 2, 1945; 2,407,680, Palmquist et al., Sept. 17, 1946; 2,415,703, Nicoll, Feb. 11, 1947; 2,426,541, Williams, Aug. 26, 1947; 2,490,662, Thomsen, Dec. 6, 1949; 2,491,761, Parker et al., Dec. 20, 1949; 2,500,801, Church, Mar. 14, 1950; and 2,511,517, Spiegel, June 13, 1950.

Heat Absorbing Glass. Patent No. 2,714,558. Filed June 24, 1952. Issued August 2, 1955. No drawings. Assigned to Libbey-Owens-Ford Glass Company by Wilbur F. Brown, Glenn C. Mook, Joseph J. Jarosi, and Curtis W. Davis, Jr.

The present invention relates generally to transparent, heat absorbing glasses and particularly to a new, low expansion, soda-lime-silica, heat absorbing glass.

A batch containing the following ingredients is proposed:

	Pounds
Sand	1000
Limestone	311
Soda ash	127
Salt cake	70
Feldspar	26
Salt	20
Borax	316
Ground coal	8.5
Rouge	5.2

To produce a glass having substantially the following average analysis:

SiO_2	69.1
Fe_2O_3	.375
Al_2O_3	.4
TiO_2	.02
CaO	11.5
MgO	.1
B_2O_3	7.8
Na_2O	10.4
K_2O	.1
Cl_2	.2
$O_2 = Cl_2$ less than	.05

A glass produced as above will have a coefficient of linear expansion of approximately .0000076 to .0000078 per degrees centrigrade; and in thicknesses of one-quarter inch it will have approximately the following transmission factors:

	Per cent
Illuminant C (daylight) transmittance	76.5 to 79
Total radiation (sun) transmittance	42 to 50

The glass is said to melt much more readily, be easier and cheaper to make and be more adaptable to working and processing than borosilicate heat absorbing glass. At the same time, it possesses a considerably lower coefficient of expansion and greater resistance to thermal shock than known soda-lime-silica heat absorbing glass.

There were 3 claims and one reference cited in this patent. 2,397,195, Mook et al., Mar. 26, 1946.

Method of Producing Filmed and Strengthened Glass Sheets. Patent No. 2,703,949. Filed November 10, 1949. Issued March 15, 1955. Three sheets of drawings; (none reproduced. Assigned to Libbey-Owens-Ford (Glass Company by Romey A. Gaiser.

This invention relates to a specially heat strengthened glass plate having a transparent, electrically conducting film on one surface and a method of producing such an article. The sheet glass is heated to 1200° F. for 3.25 minutes and is then positioned between the filming and chilling apparatus. The time interval between removal of the glass from the furnace and the application of filming solution to one side of the heated plate and air to the other, is scheduled to give a definite time lag between these two operations. In the present commercial production the time lapse between the heating and the spraying and tempering operations has been set at 5 seconds, plus or minus one second. A spray solution of 10 per cent stannic chloride in isopropyl alcohol by volume is employed and one side of the sheet is sprayed with this solution at the rate of 600 to 800 cc. per minute while at the same time an air blast is applied to the opposite side or surface of the glass from the reciprocating air pipe mechanism. The air pressures used are approximately 50 pounds per square inch for the spray solution and approximately 90 pounds per square inch for the air blast. With glass of size 14 x 16 inches the reciprocating pipe mechanism is located approximately 6 inches from the glass surface and the spray gun heads approximately 8 to 10 inches from the glass surface. Different filming fluids can also be employed, such as solutions of various tin halides, even vapors of filming materials such as stannic tetrachloride, stannic tetraiodide, stannic tetrabromide, etc., all of which can be sprayed on hot glass to produce transparent, electrically conducting films. Furthermore, non-filming fluids in liquid, semi-liquid, or gaseous form can be used instead of air to chill the unfilmed surface of the glass. Examples of these are steam, oil and mists of water-oil emulsions. The important points are, when transparent, electrically conducting films are to be produced, that the glass be heated to substantially its point of softening and that the two surfaces of the heated sheet be treated substantially simultaneously.

The patent contains 8 claims and 14 references.

Glass and Wool Fiber

Coloring Glass Fabrics. Patent No. 2,716,618. Filed September 5, 1951. Issued August 30, 1955. No drawings. By R. W. Stenzel, Herman Plaut, and G. G. Buchanan.

It is an object of this invention to impart to glass fabrics colors which will be permanent in the sense that they are fast to light, will not wash out in the conventional laundering operations, will be scuff resistant.

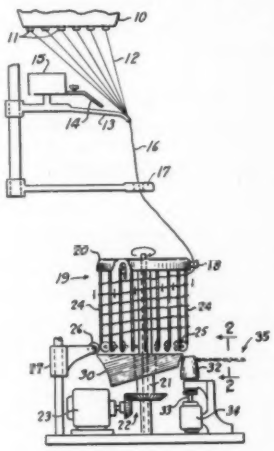
The process comprises first treating the fabric with an aqueous metallic salt solution, e.g. lead nitrate, heating the treated fabric to a emperature between 900° F. and 1200° F. to form a layer of an oxide of the desired metal adhering to the glass surface. After cooling, the fabric is treated with an anion capable of reacting with said metal oxide to form a colored compound.

In general, it is desired to treat the cloth successively with solutions which, when mixed, will produce an insoluble precipitate, exemplified above by lead chromate. In the second heat-treatment the chromate is thoroughly dehydrated and fixed to the fibers. In a quite analogous manner, other chromates can be precipitated to obtain various color effects, e.g., barium chromate, giving a yellow color, can be precipitated by using barium nitrate in place of lead nitrate indicated.

There were 5 claims and 5 references cited in this patent. 1,450,330, Negbaur, Apr. 3, 1923; 2,245,783, Hyde, June 17, 1941; 2,353,930, Smith, July 18, 1944; 2,433,292, Perloff, Dec. 23, 1947; Atlas Spans & Tweens, Atlas Powder Co. (only pages 1 and 2 relied on).

Tube and Cane Machines

Forming Staple Cordage. Fig. 4. Patent No. 2,714,797. Filed December 4, 1953. Issued August 9, 1955. Two sheets of drawings. Assigned to Owens-Corning Fiberglas Corporation by W. W. Drummond, Anderson, S. C. and P. J. Frickert, Hebron, Ohio.



This invention relates to the production of staple cordage. In Fig. 4 glass fibers 12 are led as a group over a guide 13 where they may be coated with a suitable coating substance, such as a binder, adhesive, lubricant, dripped onto the guide 13 from a nozzle 14 connected to a coating substance supply tank 15. Grouping the fibers 12 together forms a strand 16 which is led downwardly through a suitable guide eye 17 and engaged with a flyer 18 of a cap winder mechanism indicated at 19.

As the flyer 18 continues to rotate and the belts 24 continue to move downwardly, a continuous helix of the strand 16 is generated upon and moved downwardly by the belts 24. The disk cutter 26 is supported upon a bracket 27 at one side of the cap winder 19 and peripherally engaged with one of the belts or chains 24 so that it is engaged by and severs each loop of the helix formed by strand 16 as it is fed downwardly on belts 24.

As the loops fall into the trough 30 they frictionally engage the two rollers 32 which are rotated in opposite directions to feed the loops away from the trough 30.

By grasping the nips of earlier fed loops with some form of hook or other device, an operator can manually apply a slight twist to the intertangled loops and lead them to suitable twisting and/or packaging mechanism which is conventional in the cordage art and not illustrated in the drawings. As soon as the twister starts to twist the loops together the twist travels back along the mass of loops of strand indicated by ref. number 35.

There were six claims and four references cited in this patent. 2,227,911, Pool, Jan. 7, 1941; 2,262,984, Abbott, Nov. 18, 1941; 2,492,306, Mackie, Dec. 27, 1949; and 2,584,517, Verreet, Feb. 5, 1952.

(*Continued on page* 92)

Research Digest

Basic Regenerator Refractories

The cost of producing glass is affected greatly by: (1) the cost of repairing and replacing regenerators and (2) the cost of fuel. Methods of constructing and operating furnaces are determined by their effect on the cost per ton of glass. Present furnace practices lower costs by increasing throughput. As a result, the severity of attack is increased on all parts of a furnace, including the regenerators. The deterioration of regenerators lessens fuel efficiency and also heightens costs because of necessary repairs and replacements. The glass people, therefore, have been searching for a better regenerator refractory and one of the materials being investigated is the field of basic-type brick. Two papers have recently appeared describing the use of such brick.

In the first paper (Siefert and McEvoy, *Bulletin of the American Ceramic Society*, October 1955) the results of small scales tests on the use of basic brick in the regenerators of borosilicate glass wool furnaces is reported.

Table I

Type of Brick	Approximate Composition Chrome %	Magnesite %
Unburned	70	30
Unburned	30-35	65-70
Burned	100	..
Burned	70-75	25-30
Burned	35	65
Burned	..	90-95

	Fosterite		
	S_iO_2%	MgO%	R_2O_3%
Burned	33	53	12

Various types of basic brick (Table I) were placed in the checkers of the regenerators. Three different arrangements were used: (1) settings on top of the checkers two courses high arranged in a flue, (2) solid walls 9 in. thick and (3) section of conventional open setting 18 courses deep. From the basic brick placed on top of the checkers, samples were withdrawn for examination after two, four and eight weeks. The other settings, i.e., wall and conventional type, were examined after the furnace was shut down. Visual and petrographic examinations were then made of both the used and unused brick samples. The results follow:

Type A: These brick had expansion cracks and a rubble-like surface texture. The original periclase grains had disappeared almost completely. The remaining periclase grains were larger than the original ones due to regrowth. The chrome-ore grains were less affected and numerous small crystals of chromite were dispersed in the matrix apparently from breakdown along the cleavage planes of the larger ore grains. Top course samples contained high amounts of Monticellite (CaO. MgO. SiO_2) while brick from the lower parts of the checker had much fosterite ($2MgO. SiO_2$).

The attack was due largely to pickup of lime and silica. The pickup of alkali was small but, nevertheless, probably contributed to the fluidity of the matrix. The solution of periclase exposed comparatively unaffected chrome causing a rubble like surface texture. In the lower courses the brick picked up weight from the drip from the upper checkers. The cracking appeared related to the loss of bond and to the expansion resulting from the periclase to monticellite and fosterite.

Type B: Results were similar to those discussed under Type A. Chemical analyses showed a pick-up of lime, silica and alumina, even in the unexposed end of the brick. Thus, these were not just surface reactions. It was indicated that the products of reaction had considerable fluidity.

Type C: These brick cracked in service.

Type D: These brick cracked too. There was evidence of much reaction and recrystallization and of considerable attack by aluminous material, possibly caused by drip from the superstructure, as well as by the raw materials in the batch.

Type E: The results were similar to those in Type D.

Type F: These brick cracked somewhat less than some of the others tested. Products of reaction here again were fosterite and monticellite.

Type G: These brick showed shrinkage cracks. Their surfaces were changed radically by reactions between the batch dust and the brick. A light green material was formed on the surface of the brick; this was found to be a mixture of fosterite and gehlemite, apparently the end products of the reaction of the lime and alumina with fosterite. Monticellite was also formed. Secondary periclase was formed as a result of the fosterite-lime reaction.

All types of basic brick cracked and lost strength. Most of them expanded in service while one showed shrinkage. The "dryness" of basic brick under glass furnace regenerator conditions is a distinct advantage, but, nevertheless, the matrix material in some cases appears to have become quite fluid. It was difficult to choose between burned and unburned brick insofar as ability to resist attack.

It was concluded that: (1) Although these types of basic brick failed by cracking, there is evidence that basic brick compositions and methods of setting the brick can be developed to permit satisfactory service in a borosilicate furnace. To retard the attack, which was accelerated by drip from the fire-clay superstructure, tests are being made under a basic superstructure.

(2) The use of basic brick must be properly engineered. It is presently desirable to support these settings.

(3) The amount of dust carryover should be reduced as much as possible.

(4) The role played by the volatile exides of boron, sodium and sulphur should be further investigated along with the effect of oxidizing and reducing conditions. The

(*Continued on page* 96)

New Equipment and Supplies

NEW PROCESS FOR COATING GLASS WITH PLASTIC MATERIALS

Polymer Processes, Inc., a subsidiary of The Polymer Corporation, Reading, Pennsylvania has adopted a new method of coating metals, ceramics, glass, etc. and hold the exclusive license in this country. The process was invented in Germany by the firm Knapsack-Griesheim A.G. of Frankfurt-am-Main under the name whirlsintering. In the United States it will be known as the "Whirlclad" process.

This is believed to be the first process of its kind introduced by an American firm, and its purpose is to combine the natural advantages of the plastic materials with those of the parent materials to be coated. The process is said to permit use of coating materials which never before have been applied satisfactorily. The polymers used are prepared in finely divided solid form especially for the process, but are essentially pure in that they normally contain only minor modifying agents. No plasticizers or solvents are required.

The method is reported to require relatively inexpensive apparatus. It consists essentially of dipping preheated articles into a fluidized bed of plastic material, such as in finely divided solid form. Much heavier coatings can be obtained with a single dip than is customary with solvent coating methods. The melting point of the material to be coated must be higher than that of the coating material. Very satisfactory adhesion is obtained. However, to obtain the best results, the surface of the article to be coated is roughened by blasting with angular shot.

Polymer Processes, Inc., has a standard licensing program for those companies desiring to do their own coating in larger production quantities, with the necessary equipment to operate the process available under this program. A continuous system has been designed for volume coating jobs.

NEW SENSITIVE VACUUM SWITCH

The Henry G. Dietz Company, 12-16 Astoria Boulevard, Long Island City 2, New York has just announced the addition of the Cat. 110V Vacuum Static Pressure Control to its line of low pressure switches.

The Cat. 110 is easy to adjust and each unit is specifically designed for use on very low vacuums where regulation is required in inches of water column. It is applicable as an air vacuum interlock switch for use in equipment requiring safeguards to assure a specific vacuum to prevent a hazardous condition and may also be used in combustion equipment, air conditioning, industrial applications, etc.

The control is sturdily constructed and employs a dust-tight enclosure having a rubber seal. The extreme sensitivity and life of the control is made possible by use of diaphragms made of material suitable for each specific application. Range is adjusted by means of a knurled knob located outside the housing. Standard units available for 0-1″ water column vacuum and 0-4″ water column vacuum. Minimum on-off differentials of .1″ water column are available.

The electrical ratings of the SPDT switch are 15 amps. at 120-250 volts A.C. ⅛ H.P. or 125 volt amps. pilot duty.

PORTABLE POLARISCOPE

Tube Light Engineering Company, 427 West 42 Street, New York 36, New York have announced a simply constructed, low cost portable polariscope or strain detector. The efficiency of this unit is said to be exactly the same as that of any other type of full color polariscope.

This unit may be carried in the ordinary tool kit, making it unnecessary to bring the work to the polariscope. It can be used in any position and many places where an ordinary polariscope cannot be set up. As a power source this unit uses two standard flashlight batteries. A full wave retardation plate produces a violet field.

NEW "COLD" COLOR DECORATING INKS

Wornow Process Paint Company, 1218 Long Beach Avenue, Los Angeles 21, California, have developed a line of high gloss "cold" decorating colors for single trip glass containers.

The new colors, trade-marked "Cat-L-Ink" Process Colors, specifically designed for single trip containers should effect savings by decorating at the point of container manufacture, eliminating handling to and from decorating departments. Adhesion properties, durability and chemical resistance are said to be superior to any cold color yet developed.

Since the material cures permanently at 300° F. for only 10 minutes (or 375° F. for 5 minutes), further savings to the user are possible. The ink gives increased printing mileage for large coverage or fine detail and may be used on any rigid surface which will withstand the low curing temperature. Samples are available when the exact material to be printed is specified.

NEW TRIPLE GRIP VACUUM CUP HOLDER

Sommer and Maca Glass Machinery Company, 3600 South Oakley Avenue, Chicago 9, Illinois, has just introduced a new vacuum cup holder with three suction discs.

The holder is supposed to afford a more positive grip when handling or holding smooth surfaced glass or similar materials. The No. 411 "triple-grip" holder is the latest model in the Sommer and Maca line of vacuum cup holders, No. 407 being a "twin-grip" and No. 406 a "single-grip" holder. More information and prices are shown in bulletin 335-12B which may be obtained direct from the company.

CATALOGS RECEIVED

Ingersoll-Rand Company, 11 Broadway, New York 4, New York, have recently issued a bulletin, Form 9012-A describing their Barometric Steam Condensers of the Disc-Flow and Ejector-Jet types. The Disc-Flow type is a highly efficient design suitable for any barometric steam condenser application. The Ejector-Jet type is a simplified design suitable for use where the quantity of non-condensables is moderate and relatively clean cooling water is available.

These units have proved highly efficient in operation and their simplified construction results in low cost maintenance. They are available in sizes to 120″ diameter that handle up to 12,000 gallons of cooling water per minute.

Johns-Manville, 22 East 40 Street, New York 16, New York, have available a 12-page booklet entitled "Firecrete and Blazecrete."

This illustrated booklet describes the manufacturing methods used to produce these hydraulic-setting refractories for services through 3000°F., also how and where to use the five different types of Firecrete for castables. The three types of Blazecrete for gunning and slap troweling are also presented in this booklet.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during November, 1955 was as follows: *Flat Glass:* A preliminary figure of 30,000 for November, 1955 indicates an increase of only 0.3 per cent from the adjusted 29,900 reported for October, 1955. *Glass and Glassware, Pressed and Blown:* A drop of 2.1 per cent is shown by the preliminary November figure of 80,900 when compared with the October figure of 81,600. *Glass Products Made of Purchased Glass:* The preliminary November 1955 figure of 16,400 indicates a rise of 7.2 per cent from the previous month's 15,300 figure.

Payrolls in the glass industry during November, 1955 were as follows: *Flat Glass:* An increase of 4.5 per cent is shown in the preliminary $15,704,100 when compared with October's adjusted $15,033,720. *Glass and Glassware, Pressed and Blown:* An increase of 1.8 per cent is shown in the preliminary $27,340,964 reported for November 1955 when compared with the previous month's adjusted $26,866,800. *Glass Products Made of Purchased Glass:* A preliminary figure of $4,913,604 was reported for November, 1955. This is 7.8 per cent higher than the adjusted October, 1955 figure of $4,560,777.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	December, 1955
Foods	1,057,000
Medicinal and Health Supplies	1,612,000
Chemical, Household and Industrial	748,000
Toiletries and Cosmetics	836,000
Beverage, Returnable	634,000
Beverage, Non-returnable	65,000
Beer, Returnable	177,000
Beer, Non-returnable	553,000
Liquor	705,000
Wine	456,000
Sub-total (Narrow)	6,852,000

Wide Mouth Containers

Food	*3,290,000
Medicinal and Health Supplies	482,000
Chemical, Household and Industrial	172,000
Toiletries and Cosmetics	176,000
Packer's Tumblers	120,000
Dairy Products	240,000
Sub-total (Wide)	4,480,000
Total Domestic	11,332,000
Export Shipments	247,000
TOTAL SHIPMENTS	11,579,000

* This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production December 1955	Stocks December 1955
Foods; Medicinal and Health Supplies; Chemicals, Household and Industrial: Toiletries and Cosmetics	Narrow Neck	3,800,000	4,093,000
	Wide Mouth	*3,528,000	*4,132,000
Beverage, Returnable		581,000	1,198,000
Beverage, Non-returnable		56,000	226,000
Beer, Returnable		178,000	273,000
Beer, Non-returnable		625,000	797,000
Liquor		611,000	1,027,000
Wine		451,000	509,000
Packer's Tumblers		101,000	151,000
Dairy Products		235,000	294,000
TOTAL		10,166,000	12,700,000

* This figure includes Fruit Jars and Jelly Glasses.

Glass container production based on figures released by the Bureau of Census, dropped 3.7 per cent during December, 1955 to reach 10,166,000 gross. This is a decrease from the previous month's 10,557,000 gross. During December, 1954 production was 8,494,000 gross, or 16.5 per cent lower than the December, 1955 production. Glass container production for the full year of 1955 has reached a preliminary total of 136,261,000 gross.

Shipments of glass containers during December, 1955 increased 14.5 per cent to reach 11,579,000 gross. This is an increase over the November, 1955 shipments which were 10,117,000 gross. Shipments during December, 1954 were 9,047,000 gross, or 28 per cent lower than December, 1955. The preliminary total shipments for 1955 is 135,219,000 gross which is 10.3 per cent ahead of the 122,572,195 gross shipped during the corresponding period in 1954.

Stocks on hand at the end of December, 1955 were 12,700,000 gross. This is 10 per cent lower than the stocks of 14,123,000 gross on hand at the end of November, 1955 and 1.3 per cent lower than the 12,862,000 gross on hand at the end of December, 1954.

Automatic tumbler production during November, 1955 was 5,425,054 dozens. This is a decrease of 6.8 per cent from October, 1955 production which was 5,819,325 dozens. Production during November, 1954 was 5,489,352 dozens. Shipments during November, 1955 dropped to reach 5,253,177 dozens. This is 18 per cent lower than October, 1955 6,443,237 dozens. During November, 1954, shipments were 4,887,849 dozens. At the end of the 12-month period ending November 30, 1955, shipments rose to reach a total of 62,352,082 dozens, which is only 0.1 per cent higher than the 62,275,618 dozens shipped in the similar period last year.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware during November, 1955 fell off 24 per cent to reach 3,116,563 dozens. This is a decrease from the October figure of 4,125,423 dozens. During November, 1954, sales were 3,180,350 dozens. At the end of the 12-month period ending November 30, 1955, manufacturers had sold a total of 37,721,747 dozens, which is only 0.6 per cent above the 37,510,109 dozens sold during the corresponding 1954 period.

Inventing and Inventors . . .

(*Continued from page* 88)

Ampul Constricting Apparatus. Patent No. 2,718,731. Filed February 11, 1953, Issued September 27, 1955. Four sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company, by W. E. Hughes, Jr., and Otto Zauner.

The present invention relates to ampul forming machines, one commercial type of which is disclosed in Dichter Patent No. 1,962,985 issued June 12, 1934.

The chucks (upper and lower) grip a length of vertically disposed glass tubing and carry same continuously in a circular path through the necessary forming zones. Incident to such travel, the chucks rotate about their individual axes while flames play upon the selected areas of the tubing for the obvious purpose of preheating and softening the glass for elongation and subsequent constriction. The machine with which the invention is primarily adapted for use is shown in the above patent, to which reference may be had for structural details and operating procedure.

There were 18 claims and 4 references cited in this patent. 1,962,985, Dichter, June 12, 1934; 2,110,327, Dichter, Mar. 8, 1938; 262,746, Switzerland, July 31, 1949; and 423,419, Great Britain, Jan. 31, 1935.

Making Fritted Glass Tubes. Patent No. 2,714,227. Filed September 11, 1950. Issued August 2, 1955. No drawings. Assigned to Corning Glass Works by Paul N. W. Graham and Ellsworth G. Lamb.

This invention relates to the manufacture of porous glass tubes having intercommunicating pores and especially suitable for use as filters.

The invention comprises essentially introducing a slip of a powdered glass having a substantially uniform grain size into an impervious tubular mold having a deformation temperature not less than the softening point of the powdered glass and having on its inner surface a coating of a powdered refractory material which will not flux the powdered glass at the sintering temperature of the glass.

The mold is rotated about its longitudinal axis to deposit the powdered glass. The excess liquid is removed from the slip by decantation or overflow from one end of the mold to enable the powdered glass layer to retain its shape. The tubes are dried and fired in place in the mold to sinter the same without complete fusion to form a coherent porous tube having intercommunicating pores and conforming to the shape of the mold. This procedure permits the fabrication of porous glass tubes of considerable length but tubes of a wide variety of pour sizes can be made (0.9 micron or less to as coarse as 60 microns or greater).

The tubular mold must not soften or deform at temperatures below the sintering temperature of the powdered glass. Although the mold may be made of metal, it is preferably composed of a glass having a softening point not less than that of the powdered glass and an expansion coefficient substantially the same as that of the powdered glass. Moreover, the mold should be free from internal irregularities which might prevent removal of the sintered porous tube.

Any refractory material which will not react with or flux the powdered glass at the temperature of firing may be used, such as for example, SiO_2, Al_2O_3, MgO, ZrO_2, SnO_2, $ZrSO_4$, $CaCO_3$, $MgCO_3$, and various minerals including mullite, sillimanite, bauxite and corundum.

There were 4 claims and eight references cited in this patent. 1,051,638, Rodman, Jan. 28, 1913; 1,474,432, Gimson, Nov. 20, 1923; 2,125,912, George et al., Aug. 9, 1938; 2,208,034, Korach et al., July 16, 1940; 2,314,824, Greene, March 23, 1943; 330,943, Great Britain, June 20, 1930; *and Encyclopedia of the Ceramic Industries,* Searle, Publ. by Ernest Benn, Ltd., London 1929, vol. 1, page 184, "Centrifugal Separator."

Automatic Tube Weighing and Classifying Machine. Patent No. 2,710,690. Filed June 24, 1952. Issued June 14, 1955. Ten sheets of drawings (none reproduced). Assigned to Owens-Illinois Glass Company, by Gerard K. Van Steyn.

This invention relates to apparatus for weighing articles and classifying or segregating them into groups in accordance with their weight. It is especially adapted for weighing and classifying rods or tubes and similar articles. The apparatus includes means for feeding the tubes to a continuously traveling endless conveyor comprising conveyor chains with lugs for advancing the tubes singly and in succession to a weighing station where the forward movement of each tube is temporarily arrested and the tube weighed by an electric or electronic scale unit and also classified according to its weight by an electronic unit. After being weighed, the ware is carried forward and then downwardly in front of a ware receiving magazine onto which the tubes are discharged at different levels corresponding to their weight classification. The discharge of these tubes at these levels is caused by discharge fingers which are cam actuated under the control of a timer device.

There were 17 claims and six references cited in this patent. 1,750,516, Gray, Mar. 11, 1930; 1,770,810, Schoonenberg, July 15, 1930; 1,835,186, Schoonenberg, Dec. 8, 1931; 2,217,342, Ladrach, Oct. 8, 1940; 2,521,876, Stake, Sept. 12, 1950; and 2,568,255, Schieser, Sept. 18, 1951.

Sheet and Plate Glass

Glass Cutting Devices. Patent No. 2,711,617. Filed December 13, 1951. Issued June 28, 1955. Three sheets of drawings (none reproduced). Assigned to Huttig Sash & Door Company by Earl M. Trammell.

This invention relates to glass cutting devices, and more particularly to an improved power driven machine for quickly, accurately and cleanly sizing flat sheets or panes of glass. The novel features realized are provision for accurately maintaining a movable cutter in a rectilinear path, accurate adjustments for cutting different gauges and an improved automatic breakoff.

The patent contains ten claims and twelve references.

NEW POST AT M-H DIVISION

C. L. Peterson has been appointed vice president and general manager of the Brown Instrument Division, Minneapolis-Honeywell Regulator Company, it was announced recently by Henry F. Dever, president. Peterson had formerly been divisional vice president.

In this capacity, Peterson will be responsible for the direction and coordination of operations in all departments of the division.

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Atomistic Approach . . .

(*Continued from page* 79)

The importance of the hydrogen bond as a mechanism of adhesion is the low activation energy of its formation. The mobility of the protons makes it possible for the hydrogen bond to yield and reform under stresses. J. M. Stevels[15] took advantage of these features when he developed a mica substitute on the basis of glass flakes bonded by phosphoric acid. This bond is strong but promotes a certain flexibility.

According to W. A. Weyl[19] a solid is an acid if it contains poorly screened cations and a base if it contains better screened cations. At the interface of an acid solid and a more basic solid, protons tend to move from the former to the latter. This migration of protons causes an electrical potential to exist between the two surfaces which accounts for adhesion. Because of the small size and absence of electrons, the proton has the greatest penetrating power and highest mobility of all ions, thus, permitting it to move when other ions cannot.

An example of a proton transfer reaction may be found during the rubbing of a basic glass surface (high in Na_2O) with an acidic glass (high in SiO_2). When the two glasses are separated, an electrical charge is observed (friction electricity). The basic glass has become positively charged indicating some protons were transferred from the acid glass.

Effect of Long Range Order on Adhesion. Crystallization is a process in which a system loses entropy but improves the screening of its cations by surrounding them with anions in a highly symmetrical fashion. As a result one must expect that amorphous phases are better suited as adhesives than ordered ones. Screening is at a maximum with complete order.

Sugar may be mentioned as an example of the effect of order on adhesion. Crystallized sugar in the form of sugar cubes has little tendency to stick together on long standing. Hard candies, a vitreous form of sugar, have a greater tendency to stick together on standing.

On the Use of "Temporary Screening" of Reactive Molecules. Orthosilicic acid, a widely used adhesive, is usually made in the form of an alkali salt because of the rapidity of polymerization of the monomeric acid in an attempt to improve the screening of the Si^{4+} ion by more than four OH^- ions. The replacement of some protons by Na^+ ions is a convenient way to increase the polarizability of the O^{2-} ions sufficiently to screen the Si^{4+} and delay polymerization. The adhesive properties of sodium silicate to cellulose are based on a process which begins with the sharing of OH^- ions. Later, water molecules from adjacent OH^- ions are cleaved off producing a paper — O — Si — O — paper bond of high strength.

P. Lagally[9] of our laboratory used this reasoning to develop organic compounds of titanium which exhibit the property of combining with and adhering to cellulose, glass, clay minerals, and similar solids which contain OH^- ions in their surfaces. Lagally discovered that the Ti^{4+} cation in an aqueous solution of triethanolamine titanate could be temporarily screened by sugar, for example, to such an extent that it could be used as an adhesive to combine cellulose fibers with other fibers or OH^- ion-containing surfaces such as clay.

The Effect of Pressure on Adhesion. Weyl's concept of screening of cations provides a very simple explanation for the well-known work of P. W. Bridgman[2] on structural changes of substances under pressure. In AgI, for example, the Ag^+ ions are screened by four large and polarizable I^- ions (ZnS structure). Under hydrostatic pressure the electrons of the ions are forced closer to their positive cores. As a rule anions are larger than cations and are more compressible. As the pressure is increased the anions become smaller and lose polarizability by a tightening of the electron clouds. They lose some of their screening power. Four smaller less polarizable I^- ions are no longer sufficient to screen the Ag^+ ions and AgI assumes a NaCl structure with six I^- ions required to screen the Ag^+ cation under pressure.

As far as adhesion is concerned, there can be no doubt that the main function of pressure is to force the surface closer together which is helpful in every mechanism of adhesion. Nevertheless, it may be well to keep in mind, that under pressure the screening demands of cations increase and that bonds may be formed under pressure which otherwise would not contribute to adhesion.

Adhesion to Glass

In the preceding chapter an attempt was made to classify the different mechanisms which can produce adhesion. Now consider which of these phenomena are observed when a solid adheres to glass.

It seems paradoxical to apply the concept of the metal to metal bond to a glass surface. Nevertheless, the treatment of a glass with stannous chloride before silvering or with silver salts before the deposition of metallic copper from a mixture of Fehling's solution and formaldehyde can be described as the formation of a metal to metal bond. Neither silver ions in aqueous solution nor a clean glass surface are catalysts with respect to the decomposition of hydrogen peroxide. However, a glass surface treated with silver nitrate at room temperature and then rinsed with water has catalytic properties.

W. A. Weyl attributes this effect to a polarization of the Ag^+ ions which are chemisorbed at the surface of glass. Under the influence of the O^{2-} ions the Ag^+ ions are deformed. The negative fields of the O^{2-} ions repel the electron clouds of the adjacent Ag^+ ions and thus increase the electron density toward the solution. Weyl describes such a polarized cation as a unit which resembles Ag^{2+} in the direction toward the O^{2-} ion and metallic silver Ag° in the direction toward the solution: Glass O^{2-} $Ag^+ \rightarrow$ Glass O^{2-} $\frac{1}{2}$ Ag^{2+} — $\frac{1}{2}$ Ag° — solution Due to this deformation the glass assumes the catalytic property which is characteristic for silver and other noble metals. Such a glass, for example, decomposes hydrogen peroxide. Neither the pure glass nor the Ag^+ ions in solution are effective catalysts.

Weyl discussed the importance of this phenomenon for adhesion of metals to glass, in particular silvering, gilding, and stabilizing gold and copper ruby glasses. Elements which possess this property, e.g., Ag, Pb, Sn, Bi, etc., are called "metallophilic" by Weyl.

The presence of metallophilic Pb^{2+} ions in a glass may cause a "soft" lead glass to be "harder" on a cutting wheel because the lead glass can establish "adhesive bonds" with the steel disc whereas the harder glass free of metallophilic ions cannot.

(*Continued on page* 100)

WHY

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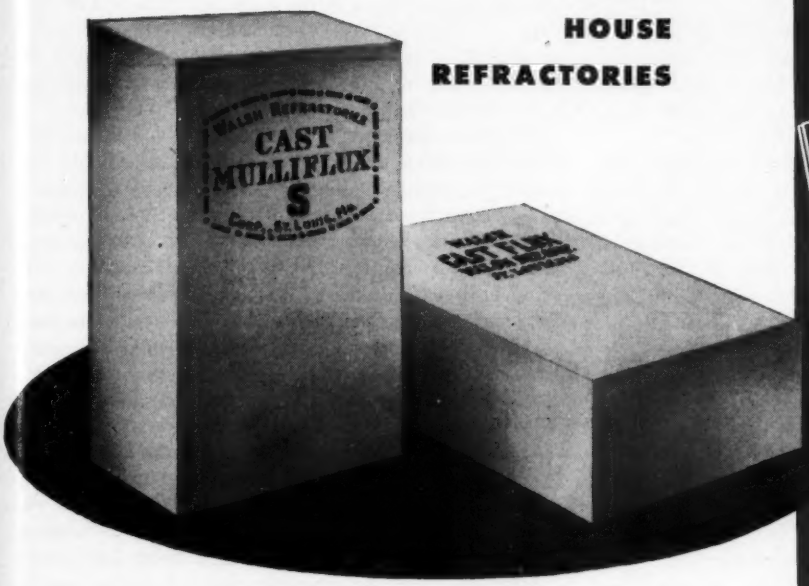

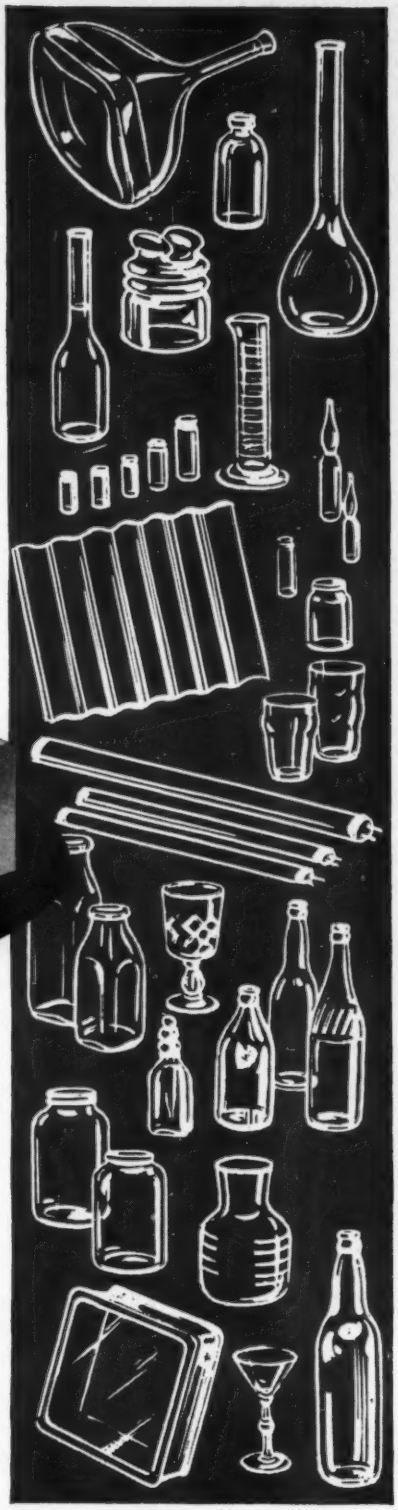

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Research Digest . . .

(*Continued from page* 89)

effect of temperature reversals in the range of those which exist in regenerators should also be studied.

(5) The basic brick used was originally developed for steel making applications. By cooperative work between the glass industry and refractory manufacturers, basic brick can be developed primarily for the glass industry.

(6) After a successful setting of basic brick has been achieved in a borosilicate furnace from the standpoint of serving a full campaign, it will be necessary to balance the increased cost of these settings against the anticipated advantages of using basic brick (such as longer life, less downtime, less slag and better fuel efficiency). It is believed that there is enough promise in basic brick regenerator applications to warrant intensive work along these lines.

In the second paper by Minshall and Hicks (*Bulletin American Ceramic Society*, November 1955) the performance records of three types of basic brick during three separate campaigns in the regenerators of the same container glass furnace are presented.

This furnace was a natural gas-fire, four side port design. The melter is 20 ft. x 34 ft. 6 in. equalling 700 sq. ft. of melting area with 15 sq. ft. in the dog house area. The depth is 42 in. with a 40 in. metal line. Operating temperatures are in the range of 2700° to 2780° F. The refiner end has a 10 ft. 6 in. radius and the regenerator chamber is 7 ft. 9 in. x 32 ft. 1½ in. (inside dimensions).

In the first campaign (18 months), the checkers had been set with 8 courses of a fired basic brick comprised of a bonded aggregate of natural olivine grains under the Number 1 and 2 port areas. The balance of the upper 16 courses of checker brick were super-duty fireclay. The lower portion of the setting-down to the rider arches consisted of first quality fireclay. All brick were 9 x 4½ x 2½ in. set in the conventional open arrangement.

The olivine brick started to break up and erode as early as nine months after the start-up. At the end of the campaign the setting of basic brick was badly disrupted having swelled to such an extent that the bulkheads at the feed end had been pushed out. Some of the upper courses of these brick had broken up, fallen into the flues and clogged them. The campaign was terminated due to the poor condition of the checkers.

In the second campaign (24 months and nine days) 12 courses of a silicate bonded periclase brick were used below the number 1 and 2 port areas. These courses consisted of 12 x 4½ x 2½ in shapes set in an open basketweave. Four courses of super-duty fire brick were below those and the rest of the 44 course setting was first quality fire brick. Super-duty were also used in the first 16 courses under number 3 and 4 ports. All of the clay brick were 9 x 4½ x 2½ in. straights laid in the conventional manner. A small quantity of 95 per cent MgO periclase brick were also installed in the top course under number 1 port on one side for test purposes.

During the first three to six months no appreciable changes were noted in the top courses of the periclase brick opposite number 1 ports. At the end of nine months the top course of brick exhibited some checking. Some of the brick had expanded and curled so that the checker setting appeared to remain in a relatively fixed state. During the tear-down it was found that the clogging took place in the clay checkers under the basic brick. For the most part the basic brick remained clean. This campaign was terminated due to the failure of the tank bottom blocks.

In the third campaign the periclase brick under number 1 and number 2 ports was extended down to 17 courses. In addition periclase brick were extended past number 3 port so that the over-all length of the basic setting was 25 ft. 2 in. as compared with 18 ft. in the previous campaign. Indications from the second campaign test of 95 per cent MgO periclase brick were excellent so these were used for the top two courses of the entire basic setting. The balance of this installation consisted of first quality fireclay topped by one course of superduty. In order to avoid the accumulation of drip from the fireclay brick in the main port crowns and sidewalls, all of these areas, except those adjacent to the number 4 ports, were rebuilt using basic brick. All periclase brick were set in open basketweave and all clay brick were conventionally laid.

The third campaign lasted 35 months and three days. When the furnace was torn down for nonoperational reasons of management, it was the unanimous opinion of those present during the tear-down, that the basic refractories in the regenerator chambers would have given an additional 12 months, and possibly 18 months, economical service. In this campaign the fuel usage was 2305 cu. ft. of glass per ton of glass produced lower than in the second campaign resulting in a total saving of $82,000 on fuel over the three-year campaign. Since thinning of the tank proper never reached the point of noticeably increased heat loss and temperature control was maintained entirely in relation to production desired. it was management's opinion that almost full credit can be given the checker setting involved as the flues remained completely open and the high thermal efficiency of the basic brick allowed a change from 20 minute reversals to 15 minute reversals, both of which lead to fuel economy.

This furnace has been rebuilt using 24 courses of periclase brick and the basic brick section has been extended to the full length of the regenerators. This section is composed of 4 courses of 95 per cent MgO periclase brick on top with the balance of the setting of silicate bonded periclase. Fireclay brick makes up the lower portion of the current setting.

UNION CARBIDE ANNOUNCES NEW DIVISION

Morse G. Dial, president, Union Carbide and Carbon Corporation recently announced a new division of the company, the Silicone Division. This division will take over the responsibility for the development, manufacture and sale of silicone products and will assume responsibilities in the field of silicones previously handled by Linde Air Products Company. Silicones, which have been marketed under the "Linde" trade-mark, will now be called "Union Carbide" Silicones.

William B. Humes, who has been vice-president of Union Carbide Canada Limited, has been appointed president of the new division.

T. J. Coleman, formerly general manager of the Linde Silicones Department was named general manager of the new division.

Comparative Tracer Tests . . .

(*Continued from page* 76)

closer to the smooth curve for machine C than for B, and points for B are closer than for A. Quality results for cords and glass breakage are best for machine C, and machine B is better than A.

The most important points to be drawn are:

1. The simplest furnace design is the best.
2. The closer the tracer points fall on a smooth curve, the better is the glass.
3. There is no correlation between time of first arrival at the machines and quality. In any furnace design, the fastest machines are generally the best.

THE CANADIAN GLASS INDUSTRY

OTTAWA.—With higher levels of construction, greater records for automotive industry's production, etc., Canada's glass industry is expected to reach a new peak of activities during 1956 and manufacturers are preparing for this upward trend in production schedules.

During 1955, despite many problems arising from rising costs and strenuous efforts by the industry to keep its prices down as much as possible, causing profit margins to be shaved on some products, the glass industry fared well. In fact, employment was much better than had been expected and average salaries as well as wages of workers in the industry continued on an upward trend for the over 8,500 workers engaged in such operations during 1955.

Moreover, the demand for glass and glass products is foreseen as probably rising during the coming months of 1956 and some companies are planning to extend their operations to enable them to take fuller advantage of the rising demand for their products. Some of these plans for modernization and expansion have already been announced but others may be forthcoming during 1956.

OTTAWA.—While at present Canada has only one mine producing nepheline syenite ore for the glass and ceramics trade operated by American Nepheline Mines Ltd., in the Blue Mountain section near Lakefield, Ontario, a second such quarry is expected to be put into operation next spring in the same area by Canadian Flint and Spar Company.

OTTAWA.—Between $5 million and $6 million will be spent by the Dominion Glass Co., Ltd., of Canada, Montreal, to improve and to modernize their plant during the next two or three years to meet an increasing demand for their products.

At the directors' meeting after the annual meeting, changes announced included President L. J. Belnap being elected chairman of the board; vice-president and general manager T. W. Bassett, was named president and general manager; secretary-treasurer Fred N. Dundas, was elected vice-president and secretary; I. R. MacDonald, a director, was elected vice-president and general sales manager; J. E. Glithero, was elected treasurer, and T. B. King, was appointed assistant secretary.

OTTAWA.—Labor costs for Canada's glass and glass products manufacturers are continuing to rise and amount to an average weekly salary and wage of $64.16 on Oct. 1, 1955 compared to $63.29 in the preceding month and $62.08 a year earlier, according to the results of the latest nationwide survey by Canadian Government covering the 8,017 regular workers in such operations.

The average hourly earnings of such workers reached 144.9¢ on Oct. 1 from 141.6¢ a year earlier and the average hours of work per week fell to 42.4 from 42.7. Employment in the industry reached 126.7 on Oct. 1 from 105.3 a year earlier, though the proportion of men employed declined since of the 8,017 workers on Oct. 1, men comprised 6,546 or 81.7 per cent and women 1,471 or 18.3 per cent, whereas a year earlier men formed 82.4 per cent of the labor force as against women 17.6 per cent.

OPEN PIT OPERATIONS BEGIN AT BORON MINE

Start of open pit mining, a major step in the $18,000,000 mining development of the world's only known sodium borate deposit, went into effect recently.

Inaugurating the conversion from 30 years of shaft-tunnel operations, J. M. Gerstley, president of the Pacific Coast Borax Company, a division of Borax Consolidated, Ltd., said the project, including construction of new refining and concentrating plants, is expected to be completed next year.

Mr. Gerstley said, "This mining method is in great contrast to 80 years ago when "cottonball" was hand picked from the floor of Death Valley and hauled to Mojave by the famed 20-Mule Teams."

The new concentration plant and refinery will handle economically all grades and varieties of ore, producing borate concentrates for export and the principal forms of refined borax for domestic use and foreign markets. Certain products, including boric acid, special borate compounds and the 20-Mule Team package products, will continue to be produced at the Pacific Coast Borax refinery at Wilmington, 135 miles south of Boron, as it has since 1924.

E. W. HARTMAN PROMOTED AT O-I

W. J. Stewart, director of personnel administration, recently announced the promotion of Ernest W. Hartman to chief industrial engineer for the Administrative Division of Owens-Illinois Glass Company.

Mr. Hartman, a native of Red Bank, New Jersey, has been an industrial engineer with Owens-Illinois since 1933. He worked first at the company's glass container plant in Bridgeton, New Jersey and has been in the general offices in Toledo since 1942.

EXCELLENT MANAGEMENT AWARDS FOR SEVEN GLASS FIRMS

Seven companies prominent in the glass industry have been certified as excellently managed by the American Institute of Management. Those named are: Anchor Hocking Corp., Corning Glass Works, Hazel Atlas Glass Co., Libby-Owens-Ford Co., Owens-Illinois Glass Co., Owens-Corning Fiberglas Corp. and Pittsburgh Glass Company.

This places them among the 408 American and Canadian firms so cited by the Institute for 1955. Six of the firms are receiving the award for the sixth consecutive year—Anchor Hocking Corp., Corning Glass Works, Hazel Atlas Glass Co., Libby-Owens-Ford Co., Owens-Illinois Glass Co., and Pittsburgh Plate Glass Company.

Atomistic Approach . . .

(*Continued from page* 94)

When a glass is melted in a platinum crucible or when a platinum wire is sealed into a soda-lime silicate glass, adhesion between the two phases is due primarily to image forces. The presence of highly polarizable and large ions interferes with this process because these ions accumulate in the surface of the fused glass and lower the surface energy because of the weak fields which they emanate. Thus, the addition of heavy metal iodides to low melting borate glasses produces melts which do not wet the platinum crucible.

If a metal is evaporated or sputtered on a glass in vacuo another mechanism of adhesion goes into effect. In this case it is customary to "clean" the glass surface by a bombardment with positive ions. It has been pointed out by W. A. Weyl and T. Forland[20] that O^{2-} ions are not as stable in surfaces as in the interior of crystals because they require an environment of cations. For this reason, O^{2-} ions in the surface of a dry glass tend to dissociate into O^- ions and electrons. This process is greatly enhanced if the surface is bombarded with positive ions, for example, by N_2^+ ions formed during an electrical discharge:

$$\text{Glass } O^{2-} + N_2^+ \rightarrow \text{Glass } O^- + N_2$$

Now the surface can react with a metal as follows:

$$\text{Glass } O^- + (Me^+ e^-)_x \rightarrow \text{Glass } O^{2-} Me^+ (Me^+ e^-)_{x-1}$$

The surface of the metal donates electrons which change the O^- ions of the glass into O^{2-} ions. The latter are stabilized by cations of the metal so that adhesion results due to the transition

glass — metal oxide — metal

The positive ions are usually produced in the sputtering unit by electrical discharge. However, flames are also a source of positive ions and it is well known that the adhesive properties, e.g., wetting of glass, are strongly affected by flaming it with a candle or a gas flame. The effects of flames upon wetting are much greater than one would expect if the process were merely a heating of the surface.

The extreme ionic viewpoint is well established in the field of crystal chemistry of inorganic compounds. As far as organic molecules are concerned, this viewpoint which is being developed by K. Fajans[3] at the present time is not yet as widely known. Many organic chemists will have no particular need for a new concept unless they work in the fields of organic silicon compounds or perfluorinated hydrocarbons and their derivatives where it is obvious that the conventional approach has its limitations. Thus, the fact that in aliphatic alcohols or fatty acids the replacement of hydrogen atoms by the heavier fluorine atoms lowers the boiling points cannot be explained by conventional concepts. The poor adhesive quality of Teflon (tetrafluoroethylene resin) is too well known to be discussed here. According to K. Fajans, a hydrocarbon chain can correspond to two different quantum configurations. The first:

$$\begin{array}{ccc} H^- & H^- & H^- \\ C^{4+} & (e^-)_2\, C^{4+} & (e^-)_2\, C^{4+} \\ H^- & H^- & H^- \end{array}$$

The second configuration is based on the ability of the

$$\begin{array}{ccc} H^- & H^+ & H^- \\ C^{4+} & C^{4-} & C^{4+} \\ H^- & H^+ & H^- \end{array}$$

carbon atoms to form two stable quantum states C^{4+} and C^{4-}. Whereas the first description is perfectly adequate for paraffin hydrocarbons, the latter applies to those compounds which contain an atom such as fluorine, oxygen, silicon, etc. Without going into the experimental proofs —for this purpose the original writings of K. Fajans should be consulted—those points which are pertinent for adhesion, shall be mentioned briefly.

The most obvious manifestation of the last configuration of a hydrocarbon chain is the fact that it must emanate alternating plus-minus forces which, in turn, can contribute to the intermolecular bonding and to adhesion.

Whereas the fields emanating from perfluorinated hydrocarbons will be those of strongly deformed F^- ions—the quantum state F^+ being rather unstable—those of fatty acids, etc., contain alternating H^+ and H^- ions. It is true that the fields of these ions are weakened through the interpenetration of the protons into the C^{4-} ions and the deformation of the H^- ions but they must contribute to the intermolecular binding forces as can be seen from the boiling points of the two series compounds.

E. C. Marboe[11] studied the adhesion of fused organic acids (dicarboxylic acids) to platinum and to glass. Oxalic, succinic, and adipic acids were found to adhere strongly but the corresponding malonic and glutaric acids did not. All these compounds have the general formula:

$$COOH\ (CH_2)_x\ COOH.$$

Conventional concepts of the constitution of these compounds do not offer an explanation for this alternation of their properties. Those in which x has the values 0, 2 and 4 adhere; those in which x has the values 1 and 3 do not adhere.

This alternation of properties expresses itself above all in the melting points and in the solubilities of these acids in water.

Summary

An atomistic approach to adhesion based on the screening concept of positive cores in solids has been given.

Methods for lowering the surface energy of solids (necessary for adhesion to occur) have been presented in the light of surface structure and a classification of the mechanisms of adhesion which are possible between surfaces and examples of each have been described.

The treatment of substances from the extremely ionic viewpoint and the application of the two basic principles, electroneutrality in the smallest volume and maximum screening of positive cores seems to provide a satisfactory basis on which one can develop the physical chemistry of adhesives. The basic concepts of solid state chemistry which W. A. Weyl used for explaining wetting phenomena and the melting points of simple compounds are used in this paper to classify adhesion phenomena. For all practical purposes two extremes are the most important: firstly, metals because they are solids with highly mobile anions (free electrons) and, secondly, organic or corresponds to a certain extent to the conventional concept of the covalent bond and the sharing of electrons.

inorganic compounds which contain protons. Protons, the only cations which do not have electrons, are mobile and can easily move from one electron cloud into another.

When two metals are brought in contact, a potential difference (contact potential) develops between the two phases because electrons move into the metal containing the cores with the greater screening demand. The metal attracting additional electrons to improve its screening assumes a negative charge leaving the other metal with a positive excess charge. This phenomenon is independent of the geometry and accounts for adhesion of metals which do not alloy or form compounds. An analogous situation occurs between two nonmetallic solids which contains protons. These mobile cations move into the solid which offers better screening. The same shift of protons which makes it possible to use the glass electrode for measuring the acidity or screening demand of a system produces a potential difference between two different substances and causes the two phases to adhere. Separation of two adhering solids by mechanical forces reveals this proton shift by the existence of a positive excess charge on the solid which offers the better screening in the same way as the separation of two different metals.

The proton shift and the sharing of anions between two solids equalizes and improves the screening of the cations in surface layers. This process of adhesion is more difficult in crystalline than in amorphous solids. Adhesives may have a very high viscosity but when amorphous they can adjust themselves to the surface of a solid. Crystalline sugar, cellulose or silicates are not sticky. Amorphous sugar, water glass, or high polymers containing OH^- of NH_2^- groups are sticky.

The "temporary screening" of a reactive compound such as hydrated titania (P. Lagally) is used to demonstrate how one can develop an adhesive on the basis of the screening theory. A molecule which normally would polymerize in order to improve the screening of its Ti^{4+} ion is prevented from doing so by the presence of molecules which provide a temporary screening, but which being water soluble, are easily removed if the titania compound comes in contact with cellulose, starch, clay, and other solids having OH groups at their surfaces.

Acknowledgment

The author is indebted to W. A. Weyl for permission to present his interpretations of adhesion phenomena in this paper. These ideas have been taken mainly from lectures presented by Dr. Weyl during the past several years to graduate students at The Pennsylvania State University.

This work was supported by the Department of the Army, Ordnance Corp, Picatinny Arsenal, Dover, N. J.

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TOLEDO MOULD NAMES JOHN HOVA PRESIDENT

John A. Hova, secretary-treasurer and a director for the past 32 years, has been named president and treasurer of The Toledo Mould Company of Toledo, Ohio. He succeeds George Arduser, who succumbed last October.

Other officers were named by the directors for the company which was established in 1918 and produces moulds for bottles, jars and pressed tableware for the glass industry were: Fred Rayburn, with the company since 1928 and sales manager since 1947, vice president in charge of sales; William Arduser, with the company since 1944 and who will continue in the engineering department, secretary; Wilbert Henning, who joined the company in 1929, chief engineer in charge of all drafting, (succeeding Albert Arduser, vice president in charge of engineering, who retired December 31, 1955, but continues as a director; and George Rohweder, with the company since 1918, plant superintendent.

Directors of the company are Mr. Hova, Mrs. John A. Hova, John Brubaker, Albert N. Arduser, Mr. Rayburn and William Arduser. The latter two fill vacancies caused by the death of Mr. George Arduser and Frank O'Neill, who died in 1954.

FLINT RECEIVES AWARD

More than two-hundred and thirty glassmen and others identified with the glass industry attended a banquet sponsored by the Northwestern Ohio Section of the American Ceramic Society in honor of Francis C. Flint, at the Toledo Club, Toledo, Ohio, on Friday, January 20th.

Mr. Flint was presented with the first Toledo Glass And Ceramic Award for his outstanding contributions to glass technology.

NATIONAL INDUSTRIAL RESEARCH CONFERENCE

"Research for Profit" will be the theme of an industrial research conference sponsored by Armour Research Foundation of Illinois Institute of Technology, Chicago, on April 18-20, 1956, on the Illinois Tech campus.

The meeting, titled the National Industrial Research Conference, will highlight a series of 12 technical meetings, part of the Foundation's 20th anniversary.

A number of leading industrialists and research directors will participate and twelve papers will be presented at the conference.

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CRESSY PROMOTED AT EMHART AND THREE NEW APPOINTMENTS AT HARTFORD-EMPIRE

Morton S. Cressy has been named vice president-sales of Emhart Manufacturing Company, a new position, in a move to expand the sales activities of all Emhart divisions. Three advancements in the Hartford-Empire division were announced at the same time.

M. S. Cressy

W. B. McKinney

In his new post Mr. Cressy will guide the development of sales activities in the Hartford-Empire glass machinery division, which he has been with since 1947; the Standard-Knapp packaging machinery division in Portland, Conn.; the V & O Press Company division in Hudson, N. Y.; and the Henry & Wright division.

Prior to joining Emhart's Hartford-Empire division, Mr. Cressy had been in executive capacities with American Cyanamid Company.

C. F. Claughsey

A. K. Lyle

Moving to the post of general sales manager at Hartford-Empire is Walter B. McKinney; he joined the company in 1940 as field engineer.

Aaron K. Lyle will be technical manager of the division and Charles F. Claughsey is chief application engineer. Mr. Claughsey's career at Hartford started in 1932 and he has been closely associated with the development of the firm's glass container forming machinery.

Mr. Lyle came to Hartford-Empire in 1937 as a glass technologist, later becoming chief chemist. He is a fellow of the American Institute of Chemists and has, at various times, been a vice president, chairman of the glass division and a trustee, all of the American Ceramic Society. He is internationally known for the many articles he has contributed to various technical journals in the glass field.

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BORAX	Sodium Tetraborate. $Na_2B_4O_7 \cdot 10H_2O$. Coarse and fine granular and powdered grades.
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and a diversified line of specialized agricultural and refrigerant chemicals

Polish Papers of Interest . . .

(*Continued from page* 85)

Table III shows heat losses through furnace walls in relation to the thickness of insulation.

Table III

Thickness of insulation	Temperature inside surface of insulation °C	Temperature outside surface of insulation °C	Heat loss in Kcal/m²/hour	Decrease in heat losses per cent
0	..	..	6600	..
2.5 mm	925	220	3570	46.0
5.0 mm	1127	170	2370	64.0
7.5 mm	1220	150	1790	72.8
10.0 mm	1265	133	1430	78.3
12.5 mm	1308	120	1200	81.8

(No description of furnaces given.)

METHODS, ERRORS AND FAULTS IN GLASS ORNAMENTATION

Eryk Rozewicz. *Szklo i Ceramica* (*Glass & Ceramics*) 9, No. 6, p. 207-211, 1955.

Baking of paints in the oven should be done with plenty of air to burn off the vehicle. Temperature should increase slowly to 300° C. This will eliminate shadows from carbon and blisters from quick drying.

A proper gloss and purity of ornamentation is obtained, when the inside walls of the muffle oven are covered with an insulating glazing prepared from a following mixture:

32 parts by wt. minium
8 parts by wt. sand
1 part by wt. borax

This formula is especially useful when the paint contains lead.

A good preparation for cold printing consists of:

5 parts by wt. golden yellow venetian turpentine
1 part by wt. clear colophony
15 parts by wt. rectified turpentine oil

or

3 parts by wt. golden yellow venetian turpentine
1 part by wt. resin
10-15 parts by wt. rectified turpentine oil

Colophony or rosin should be pulverized, mixed as above and kept in a tall stoppered bottle at 30° C. This preparation should be placed on the object in a thin layer to assure good sticking of pigment and good parting of paper from the pigment.

A good method to prevent darkening of silver ornamentation is to cover it with a thin layer of gold paint.

CARBORUNDUM PLANS EXPANSION OF "MONOFRAX" REFRACTORIES PLANT

The Carborundum Company will spend $1,500,000 to modernize and expand its "Monofrax" Refractories plant in Falconer, New York, according to an announcement by General Clinton F. Robinson, president.

The expansion program will be accomplished in progressive stages during the next five years. The building schedule calls for completion, in 1956, of a new building for storage and handling of raw materials and other supplies. New transformers will be installed to provide increased power for the electric furnaces. New materials handling and production control equipment will be installed in the present plant to improve quality control and expedite production.

Additional employees will be required for the increased production schedule and over the five year period it is anticipated employment in the Falconer plant will be increased substantially.

RALPH REISGEN ELECTED A VICE PRESIDENT AT PITTSBURGH PLATE

Election of Ralph V. Reisgen as vice president in charge of glass manufacturing has been announced by David G. Hill, president. In this position, Mr. Reisgen succeeds Mr. Hill, who was elected president of the Pittsburgh Plate Glass Company.

A native of Kokomo, Indiana, Mr. Reisgen joined Pittsburgh Plate during 1915 as an apprentice pattern maker at Ford City, Pennsylvania. The following year he enrolled at the University of Pittsburgh where he earned the degree of B.S. in mechanical engineering.

He returned to the Ford City plant in 1922 as a booker and construction clerk and later served as assistant master mechanic and plant engineer. He was first assistant superintendent at the Ford City plate glass plant from 1950 to 1952 when he was transferred to the company's general offices in Pittsburgh as general superintendent of plate glass factories.

NEW APPOINTMENTS AT CORNING GLASS

The appointment of Edward A. Cook as project engineer in Transportation Services at Corning Glass Works, was announced recently by Dr. Charles F. DeVoe, the company's director of manufacturing staffs.

In his new capacity, Mr. Cook will be responsible for company-wide projects involving warehousing and shipping operations.

Also announced, by the company, was the appointment of John T. Lanahan to the newly established position of assistant director of public relations. Mr. Lanahan has been with the company since 1944.

Manager of the department's Corning office for the past two years, Mr. Lanahan will be succeeded in that position by Robert L. Edwards who has been a member of the staff since 1953.

Lloyd W. Larson has been named director of training for Corning Glass Works was announced by Thomas Waaland, company vice president and director of industrial relations.

Mr. Larson, who has been supervisor of personnel at CGW's Parkersburg, West Virginia, plant will be succeeded in the post by Arthur C. Rutan, former plant supervisor of personnel at Harrodsburg, Kentucky.

Key Points Where It Pays to Specify B&W Specialized Refractories

Operators of glass melting furnaces know best the properties of refractories that they need in various tank locations.

Many manufacturers are choosing B&W Allmul, Allmul-D, B&W 80, 80-D and B&W Junior Firebrick for ports, checkers, regenerator crowns and walls. B&W Insulating Firebrick are also used for those sections of the tank that may require insulation.

Individual choice of a particular brand for a specific area varies, of course, with kind of glass melted, rate of pull, design of unit and other operating considerations. A container manufacturer found that B&W 80's were the most economical for specific checker locations, while another, producing tubing uses B&W Junior Firebrick in similar checker areas. B&W 80 Firebrick are used in burner blocks of a tank producing pressed ware, while manufacturers of borosilicate, container and window glass, for like applications, use B&W Allmul.

The one common requirement in all these applications is the uniform need for B&W *specialized refractories* to provide adequate performance.

For your next tank rebuild, we suggest calling in your B&W representative to get complete details.

Properties of B&W's Specialized Firebrick

	B&W Allmul	B&W Allmul-D	B&W 80	B&W 80-D	B&W Junior
Recommended use limit, F	3200	3200	3050	2950	2850
Fusion point, F	3335	3335	3190	3190	3173
Hot load strength, % deformation, 25 psi, 1½ hours	Less than 2% @ 3050F	Less than 1.2% @ 3050F	Less than 1% @ 2640F	Less than 0.5% @ 2640F	Less than 1.5% @ 2640F

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RADO

KNOX GLASS PROMOTES J. B. SHIMER

Dr. A. W. Wishart, president of Knox Glass, Inc., announces the appointment of J. B. Shimer as manufacturing manager. Mr. Shimer had been manufacturing consultant for the company since September 1, 1955.

A graduate of Lehigh University in Chemical Engineering, Mr. Shimer was with DuPont Rayon until 1930 when he became associated with the Corning Glass Works as a member of the Research Laboratory. Later he was assistant chief engineer, assistant plant manager and plant manager at various Corning plants. In 1946 he joined the Kimball Division of Owens-Illinois Glass Company as plant manager—Television Operations, advancing to general factories manager—Television Operations. Immediately prior to coming to Knox Glass, Inc., he was general manager of Buck Glass Company.

● T. G. Warder, formerly superintendent of the Hazel-Atlas Glass Company's Pomona, California glass container plant, has been appointed superintendent of the company's newest glass container plant now under construction at Plainfield, Illinois.

ADDITIONAL NOTE ON BOOK REVIEW

Proceedings of the Symposium on the Fining of Glass

The December issue, page 651, of THE GLASS INDUSTRY carried a book review about the publication on the Proceedings of the Symposium on the Fining of Glass, held in Paris from June 12 to 23, 1955, which The Union Scientifique Continentale du Verre is preparing. We would like to add that the papers written in English, or German will be published in the original language.

The volume will contain 13 papers in English, 13 papers in French and 3 papers in German, one paper in Italian, together with a French translation.

H. F. WELCH APPOINTED PERSONNEL DIRECTOR GLASS CONTAINER DIVISION OF O-I

Appointment of Harry F. Welch as personnel director for the Glass Container Division of Owens-Illinois Glass Company has been announced by R. A. Cosh, vice president and division general factories manager. Mr. Welch succeeds W. B. Owen.

A native of Alton, Illinois, Mr. Welch has been with O-I and its predecessor, Illinois Glass Company since 1923. He held various positions at the company's glass-container plant in Alton until 1936, when he was assigned to the general offices in Toledo as a statistician in the general manufacturing department. He was wage and salary supervisor for the Glass Container Division.

● Russel W. Mumford, vice president and consulting engineer for American Potash & Chemical Corporation, retired recently after 35 years service with the company.

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H-W CORUNDUM is an extremely hard fired refractory consisting entirely of corundum (99+% crystalline alumina). Its properties of particular importance for use under the most severe operating conditions are high refractoriness, substantially equivalent to that of pure alumina (3700°F.), exceptional volume stability and resistance to fluxing by alkalies at high temperatures.

KORUNDAL brick is a 90% alumina refractory having a homogeneous mineral composition of corundum bonded with mullite. It is used in standard sizes and special shapes with great benefit under conditions of thermal shock, soaking heat and severe fluxing conditions at very high temperatures.

H-W MULLITE is made synthetically rather than from the natural minerals of appreciably lower alumina content. Its alumina content closely corresponds to that of pure mullite. Because of its high degree of stability and its fully developed mineral composition, H-W MULLITE is unusually resistant to fluxing by corrosive dust and volatile alkalies. In addition, the superior physical properties contribute to the excellent service secured from this unusual synthetic mullite refractory.

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O-I FORMS NEW DIVISION, APPOINTS J. L. GUSHMAN AND J. D. NORTHUP

J. L. Gushman

J. D. Northup

Owens-Illinois Glass Company has announced the formation of a new International Division with John L. Gushman, administrative division vice president, as general manager.

The new division will be responsible for all O-I business outside the continental limits of the United States, including sales, manufacturing, investments, licensing and the sale or lease of machinery and equipment.

It will have parent company policy supervision over Owens-Illinois Inter-America Corporation, a subsidiary responsible for the sale of O-I products in the Western Hemisphere.

John D. Northup, director of engineering, has been appointed a vice president in the administrative division and succeeds Mr. Gushman as head of administrative services.

AGA ELECTS TWO MEMBERS AT LARGE AND ONE ALTERNATE TO BOARD OF GOVERNORS

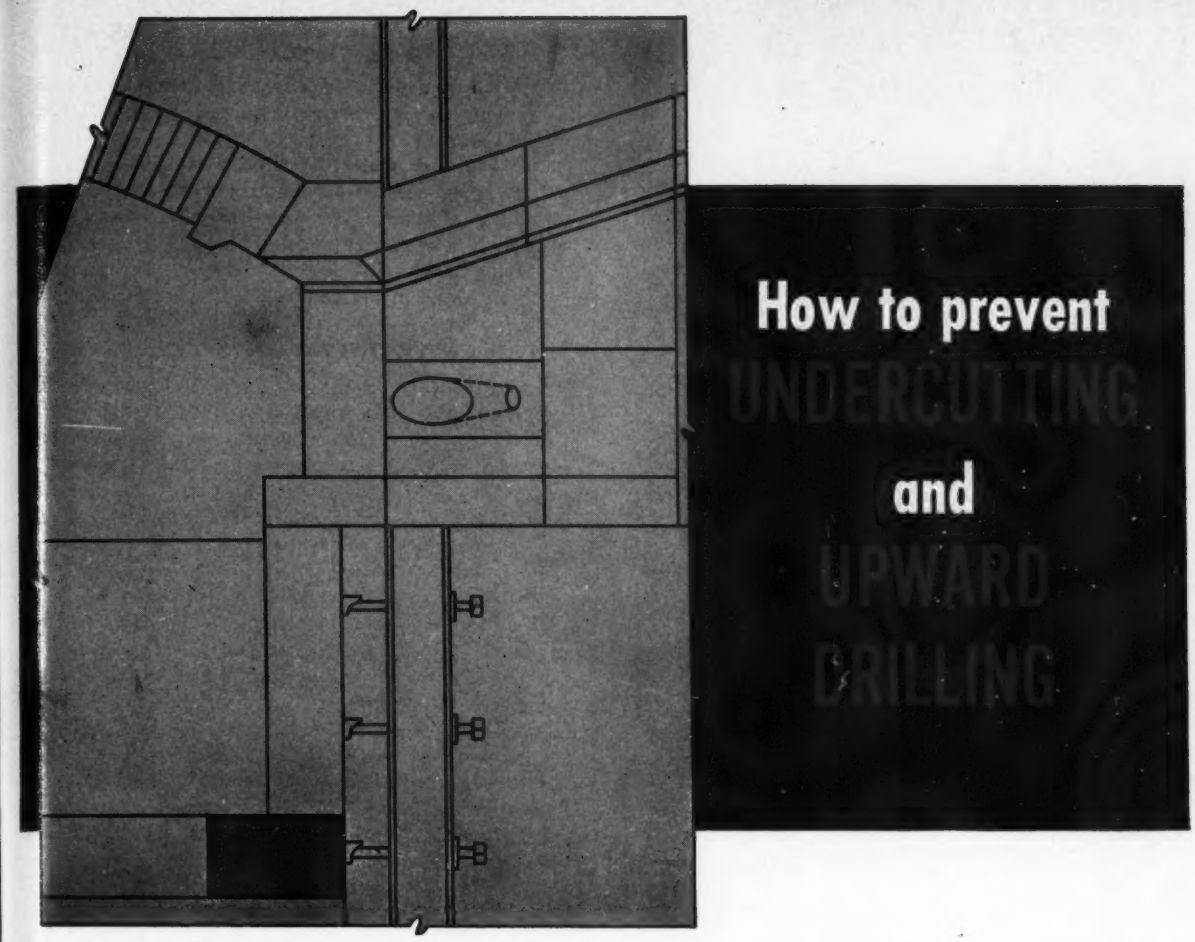
As directed by Article VII, Section 2 of the A.G.A. Constitution and By-Laws, a secret mail poll of the member companies has elected the following to its board of governors for a period beginning January 1, 1956 to December 31, 1957 and thereafter until their successors will have been duly elected.

Representing the membership at large: W. F. Dalzell, president, Fostoria Glass Company, Moundsville, W. Va.; E. A. Donnan, president, Federal Glass Company, Columbus, Ohio; and alternate at large, R. M. DeGarmo, vice president, Thatcher Glass Manufacturing Company, in charge of McKee Division, Jeannette, Pa.

CORNING ACQUIRES AMELUNG PAIR

A significant addition to the American collection of The Corning Museum of Glass, Corning Glass Center, was made this week when Corning acquired the only known pair of Amelung presentation goblets.

The significance of this acquisition is heightened by the fact that these goblets bear the latest recorded date of any engraved Amelung piece discovered thus far. The pair was acquired from Mrs. Christian Thomas of Wytheville, Virginia, in whose family the pair had been for generations. Of the few Amelung presentation pieces to survive, no other pair is recorded. Both goblets in the pair are dated 1793, which is the last date on record for anything from the factory of John Frederick Amelung.



Installing Monofrax® fused cast refractories is a simple, sure answer to these hazards of the base block area.

Joint between base and side wall blocks stays well protected despite convection currents and despite the corrosive action of molten glass. The dense, tightly interlocked crystalline structure of the Monofrax® refractories forestalls excessive undercutting followed by upward drilling. As the side walls are given constant, level support there is less chance of possible glass leakage and eventual failure here.

This same feature of Monofrax® M blocks, by the way, is also used to excellent advantage in tank side walls. In fact, base and side wall blocks of this material form a combination that stands up to the toughest glass furnace service.

High alumina, purity and absence of interstitial glass combine in Monofrax® refractories to insure maximum life with a minimum of refractory-caused problems. Carefully made to close tolerances, these blocks give tight-fitting, more durable structures.

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L.O.F GLASS FIBERS EXPANDS FACILITIES FOR WINDING YARN

Expansion of facilities of direct importance to the electrical industry has been announced by L.O.F Glass Fibers Company.

At its plant in Waterville, Ohio, a completely new section is being devoted to multiple winding of yarn for the electrical trade. The new facility concentrates the company's activity and greatly increases its capacity for producing braider and serving packages. Thomas Kiger has been placed in charge of the new operation.

ACS' CENTRAL OHIO SECTION MEETING

The Central Ohio Section of the American Ceramic Society inaugurated a new policy for its meeting programs. Henceforth, instead of having a program committee to plan all the programs for the year, each meeting will be assigned to a different group within the Section. This group will be responsible for arranging the meeting, selecting the meeting spot and obtaining the speaker. This arrangement is expected to produce programs of a more diversified nature and higher quality.

If the initial meeting is any indication, the new arrangement should be a huge success. Dr. J. O. Everhart and the staff of the OSU Engineering Experiment Station presented the first meeting, January 13.

Dr. Herbert Insley presented a technical discussion on phase diagrams which was highly informative and interesting to all ceramists. Dr. Insley is internationally known for his research in the microstructure and chemistry of mineral products. Presently, he is an independent consultant in the fields of ceramics and mineralogy. He is also a consulting editor to the *Journal* of the American Ceramic Society. Dr. Insley had served as chief of the Mineral Products Division of the National Bureau of Standards for six years prior to his retirement from that position in 1953. Probably his most famous work, indispensable in ceramics libraries, is "Phase Diagrams for Ceramists," which he co-authored with F. P. Hall. For this work, the two men were chosen as the first recipients of the Ross Coffin Purdy Award of the American Ceramic Society.

The annual election of officers was held at the previous meeting of the Section. The new executive committee consists of: chairman, J. F. Lynch of Battelle; chairman-elect, C. E. Evans of TAM Division of National Lead; vice chairman, G. R. Machlan of Owens-Corning Fiberglas; secretary, W. B. Shook of *OSU Engineering Experiment Station;* and treasurer, P. D. Dilliard of Anchor Hocking.

Fifty-one members and guests were present to witness Dr. Pool's talk on "Atomic Energy as Slanted by the Geneva Talks." Several past presidents of the Society were present amongst the audience: Professor Watts, Dr. Bole, J. D. Sullivan, and Ray Pafford, as well as several trustees of the Society.

● Kenneth F. Bernatz, formerly with Hyalyn Porcelain, Inc., Hickory, N. C., has joined the technical staff of B. F. Drakenfeld & Co., Inc., New York.

After a period of training at the company's factory and laboratories in Washington, Pa., where he will make his headquarters, he will be engaged in sales service work.

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WATTS CHOSEN FOR BLEININGER AWARD

Arthur S. Watts, professor emeritus, Ohio State University, Columbus, Ohio, has been named the 1956 recipient of the Albert Victor Bleininger Award.

The award is the highest honor conferred in this country for distinguished achievements in the field of Ceramics and is given annually by the Pittsburgh Section of the American Ceramic Society.

The medal and scroll representing the award will be presented to Mr. Watts at the Bleininger Award Dinner to be held March 16, 1956 at the Hotel Schenley, Pittsburgh, Pennsylvania.

LOF BEGINS GLASS BENDING AT EAST TOLEDO PLANT

Glass bending operations are now under way in the large new addition to the East Toledo plant of Libbey-Owens-Ford Glass Company was announced by plant manager, Henry M. Dodge.

Two new bending furnaces have been installed in the addition to the large new laminating plant. The bending department is new to the East Toledo plant and together with the new plate glass manufacturing facilities enables the plant to handle a complicated panoramic windshield from the raw material for glassmaking to the finished product. Bending furnaces were put into production before the building contractors had the entire large addition completely closed in.

This new structure is 680 feet long by 240 feet wide and has an L-shaped section 80 feet wide and 397 feet long. It will also house an additional autoclave for laminating safety glass, edging equipment, windshield storage and shipping facilities. General foreman for the bending department is Charles F. Clark.

PPG PLANS EXPANSION OF SHELBYVILLE FACILITIES

The board of directors of Pittsburgh Plate Glass Company has approved expansion of the Shelbyville Fiber Glass manufacturing and storage facilities, it was announced by G. Donald Campbell, manager of the local Fiber Glass manufacturing unit.

Preliminary plans call for a building addition designed to increase continuous fabrication production facilities and to provide needed warehouse space for superfine fiber glass storage. Additional fabricating and twist and ply equipment will be added.

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